THE

ELECTRICAL REVIEW.

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CONTENTS:

	PAGE
The Selection of Steam Engines	585
Power Transmission by Three-phase and Continuous Currents	587
Evaporative Condensers	588
Stone's Compound Telephone Conductor (*illustrated*)	588
The Utilisation of Water-power by Electric Transmission ...	589
The River Plate Telegraph Dispute	590
Ocean Depths	591
How and What to Study	592
The Opening Day of the Brussels International Exhibition ...	593
The Discharge of Conductors in Circuit with Variable Capacity, Resistance, and Self-induction	594
Conductivity of Incandescent Carbon Filaments and the Space Surrounding them	594
The Electrical Industry at Newcastle	596
Central Electric Station of the Davis Coal and Coke Company	598
An American View of the Metric System...	599
Correspondence:—The Function of the Element in Cable Speeds	600
Submarine Cable Breaks and Repairs	600
On the Dielectric Constant of Liquid Oxygen and Liquid Air ...	600
The Limiting Velocity of Belt and Rope Gearing	602
Business Notices, &c....	602
Electric Lighting Notes	604
Electric Traction and Motive Power Notes	605
Telegraph and Telephone Notes	606
Contracts Open and Closed	606
Notes	607
City Notes	610
Traffic Receipts	610
Share List of Electrical Companies	611
Reviews:—The Hydro-Electric Methods in Medicine	612
Hydraulic Machinery	612
Practical Electrical Measurements (*illustrated*)	613
Multiphase Induction Motors (*illustrated*) (*concluded*)	613
Proceedings of Societies:—	
The Institution of Electrical Engineers (*illustrated*) ...	615
The Dover Corporation Electric Tramways	618
Corrosion and Scale from Feed Waters	619
Australasian Electrical News	619
New Patents	620

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THE SELECTION OF STEAM ENGINES.

UNDER this head Mr. W. H. Wakeman, in an American contemporary, presents to the steam user some good advice on purchase and choice of a steam engine. The question is just as difficult, we might add, to-day as it was in the days when the old nominal horse was trotting about, for now that we have the brake horse-power, the indicated horse-power, the electrical horse-power, and the effective horse-power, the uninitiated or non-technical steam user finds himself quite unable to manage a four-in-hand; and so long as purchasers are not engineers and do not understand the technicalities involved, they have only themselves to blame when they buy machinery without competent advice. The power of an engine is not to be measured simply from its cylinder dimensions, or its speed, or the boiler pressure. All these go to make the power as well as the point of cut-off, and by asking for an engine of a given power one may get half a dozen sizes offered by as many builders, and the unscrupulous seller may offer a certain power at a much lower rate than the more honest man who has assumed economical conditions and cannot sell a 50 H.P. engine as cheap as the man who has based his calculation of 50 H.P. on steam carried through the stroke with no expansion. On the question of high speed, Mr. Wakeman, who is a practical working engineer, says high speed means more friction and this means more expenditure of oil. It may be true that high speed results in steam economy where everything is in perfect order, but the increased friction means leakage at valves and pistons, and he sums up "high speeds are not an unqualified success and will never be universally adopted," a rather strong expression of opinion, but one that is common to experienced steam engineers who have found themselves unable to trace where, in either comfort, upkeep, or economy, the high speed class of engine favourably compares with the older type. The steam user is further warned not to trust to estimates of power required as based on the requirements of machinery in good order. In a saw mill, for example, the boards to be planed call for a heavier cut than usual, the knives are not at best, the circular saw is not keen, and so on, while in every works the tendency to pile work on the engine by adding new machinery is very great and warrants the purchase of an engine too big for its work. Several means of increasing the power when needed can then be followed. The pulley can be changed and the engine run faster, or the boiler pressure may be raised if it had a margin allowed when new for a prospective increase, and the cut-off may be made later, or if the engine has been non-condensing

it can have a condenser department added to it, or in some cases one engine of a pair may first be laid down and the second cylinder added later. In cutting down the price of an engine, a steam user is very apt to cut down the quantity and quality of what he is buying fully as much as he cuts down the price. In this way engines without proper support under the girder frame, with crankshafts of too small diameter bending under the wheel load and throwing all wear on the inside ends of the bearings, and with altogether too small a margin on everything, will be sold to the user. Mr. Wakeman disbelieves in flat slide valves, of which so many have been used on American engines. Valves that can be turned, seats that can be bored, seem to him more rational. The guides are an important detail. They are variously flat, round, and V-shaped. The first have many merits. Oil does not gravitate off them; they can be arranged so that the crosshead drags some oil at every stroke from the oil catcher to the slide surface. They ought to be loose and bolted to the engine frame, so as to be removable for repairs.

When bored out guides are used, there is not so much chance of the crosshead binding fast: they will last well with little or no wear, but if they get even partially dry they soon cut, and the whole surface is quickly ruined. They do not carry oil well for its tendency is to gravitate from the higher portions. V guides have the one recommendation of holding the crosshead rigidly in position. They are usually Babbitted, and, if neglected, this melts, but repairs are soon effected; they are bad to lubricate owing to the action of gravity.

Mr. Wakeman strongly recommends metallic packing, and when we think of the enormous waste of power that accompanies too much tightened fibrous packing, we fully agree with him. But metallic packing has its drawbacks. It permits steam to enter: it adds, in fact, to initial exposed surface and promotes cylinder condensation, but, undoubtedly, it is on the whole a great improvement upon fibrous packing.

Stop motions as a safeguard against excessive speed are strongly advised. In Lancashire practice where excessive speed is of course a danger and under speed tends to the production of soft yarns, the knock off motion is made to act between very narrow limits, so that the engine will stop whatever may happen to the governor. No cast-iron fly-wheel rim should exceed a velocity of 80 feet per second, nor should the arms be too wide apart, as the rim may bulge between the arms if these hold in the parts attached to them. This is claimed to have been proved at high velocities. Wheels have already been built up of steel plates and angles, &c., and we anticipate an increase of this class in the future if high speeds continue.

Electrical Power from Nile Cataracts.

In connection with the suggestions of Professor Forbes, under the consideration of the Egyptian Government, to utilise the water-power of the second Nile cataract, referred to in our issue of April 23rd, p. 551, we have made some further investigation of the scheme, the works of which have now been in hand for two years, for utilising 16,000 B.H.P. of the power in the falls of the Rhine at Rhinefelden. There is some similarity in the conditions of the two rivers; except that at the time of mean low water in both, the volume of the Nile is at least three times that of the Rhine; while at high water the volume of the former is at least 18 times that of the latter. The rise of the Rhine is intermittent; for instance, during February of this year an abnormal rise occurred which caused an unforeseen interruption in the work in hand. The recurrence of the rise of the Nile at the same time each year may be counted on though the height may vary as much as between 6 and 10 metres. The banks of the Rhine are alluvial with a rocky limestone bed, easily quarried. At the Nile Cataract the river bares a reef of the hardest crystalline formation, and the banks are of the same formation, filled in with drift sand from the desert. The fall at Rhinefelden partakes of all the characteristics of a cataract or rapid, the incline of the *bed* having an average of about 1 in 150. Under the conditions above described, it may, we think, be fairly estimated that to utilise the Nile at all, it will require works of at least five times the scale of those now in progress at Rhinefelden, and that *pari passu* it would not be worth while considering the details of any scheme to do so, unless a demand for $5 \times 16{,}000 = 80{,}000$ B.H.P. could be anticipated. In our next issue we shall attempt to carry the investigation a little further in view of the facts already evidenced by the forward state of the large capital expenditure on the works incurred and contemplated at Rhinefelden.

Calcium Carbide.

Two recent improvements in the preparation of calcium carbide are to be noticed. The first is by T. L. Willson, of New York (U.S.A.). Lime and coke which have been finely powdered and then thoroughly mingled in a grinder or mixer, in the proportion of 35 per cent. of coke and 65 per cent. of lime, are fed into a vertical furnace enclosed in brickwork, and preferably lined with carbon, and provided with a tap-hole at the bottom for the removal of the fused product. The lower electrode is formed of broken carbon, and the upper, which is removable, is of compacted carbon, and is connected with an adjusting mechanism by which it may be raised or lowered. The electrodes are connected to the poles of an alternating current dynamo having a mean potential of 55 volts, and the reversals of the current may be satisfactorily run at about 50 a second. The amperage, which depends on the size of the furnace, may be 1,500 amperes for a pole of 8 inches on the side. It is claimed that by this process the difficulty of feeding in between the poles is overcome, and that the output of calcium carbide per electric horse-power is nearly double that which is obtained with a direct current. The second improvement is by Raoul Pictet, whose laboratory at Geneva, in Switzerland, has attained a world-wide reputation in connection with his researches on low temperatures, and especially lately in connection with his successful efforts to purify acetylene produced from calcium carbide. A cupola is provided with a ring of tuyeres at about two-thirds of its height from the bottom, and with a ring of blow-pipes at about one-third of its height; the electric arc is formed at the bottom of the furnace. Air is injected through the tuyeres, and hydrogen and oxygen (water gas and enriched air) respectively through the separate pipes which form each blow-pipe. The charge of lime and excess of coke is heated by the combustion of a part of the coke to 2,000° C. at the tuyeres to 2,400° C. at the blow-pipes, and to above 3,000° C. at the electric arc. Here the calcium carbide is formed, and flows from the bottom of the furnace in a fused condition, making room for a fresh charge at the top. To protect the furnace lining from the heat of the arc, the exit pipe is made to protrude into the furnace, so that a residuum of calcium carbide remains in the bottom of the cupola, where it partially solidifies on the lining.

POWER TRANSMISSION BY THREE-PHASE AND CONTINUOUS CURRENTS.

By G. L. ADDENBROOKE.

I CANNOT help thinking the ELECTRICAL REVIEW and its contemporaries were "too previous" in publishing leading articles on Mr. Esson's paper before the whole of it, and particularly Mr. A. Siemens' contribution to the discussion was published. At the same time, it appears a pity that the questions raised should be passed over without further notice, though it is doubtful if this question is at all suited for controversy, or is it likely to be settled by controversy? What has been the history of controversy in theology, and what of the great alternating *versus* continuous current controversy which raged so keenly for some time. The theologians have remained where they were, and so have the two sides in the electrical controversy. Is it not probable that a continuous *versus* three-phase power transmission argument on the same lines would end in the same way? I suspect so.

There is a method, however, by which progress is attained. While theologians have been disputing without advance, patient enquirers into truth have learnt to decipher hieroglyphics have narrowly examined old M.S.S., have ransacked ruins and tombs, and without entering directly into the controversy have brought to light new facts which have either made the old disputes appear frivolous or have altered their character entirely.

So in the electric lighting dispute, both parties were very equally balanced and remained so for some years, and do remain so now on the old basis, but in the meantime, while the combatants rested on their oars, another lot of workers have evolved a better lamp at 220 volts than the old ones were at 100 volts. Enclosed arcs taking a higher voltage have been perfected, and, lastly, accumulators have been reduced largely in price, and are now capable of being discharged regularly in two to three hours instead of in six.

Here again progress in other directions has changed the whole groundwork of the dispute.

Now let us come to three phase *versus* continuous current power transmission. The only method of treating these correctly is to do as Mr. Crompton did for lighting systems, namely, compare the two together as accurately as possible. Eliminate everything which is common to both, and reduce the differences within the narrowest compass and compare these. Should these appear fairly balanced as they did in the case of lighting systems, the only thing to do is to look ahead and see in what direction reasonable progress and new development is likely to take place, and try and estimate what influence this will have.

In the first place, the cost of continuous and three-phase plant, both motors and generators, is very appreciably the same, and seems likely to remain so, perhaps with the royalty rather more for three-phase. A good deal has on the other hand been made of the cost of three-phase starting resistances and appliances, but those who have had anything to do with starting resistances for high tension continuous current motors know that these with their attendant appliances are no trivial matter, in fact, as far as I can judge, worked out on a similar basis, there is very little to choose between in the cost of these appliances in either case.

Next we come to the line. There is a good deal of uncertainty about this, and some difficulty in getting to the bottom of the real meaning of the various authorities who have laid down the law on the subject. Looking at the matter, however, from a practical and engineering stand point, the facts are, however, I believe as follows.

The maximum voltage of alternating currents is $\sqrt{2}$ above the mean, and apparently there is some greater strain on a cable conveying an equal virtual alternating than on a cable carrying an equivalent continuous current. There is evidence, however, tending to show that this greater strain is rather due to the rapid reversals of the current than to the momentary higher voltage. The difference which a cable manufacturer could make in the cost of a cable to convey, say, 3,000 virtual volts alternating as against 3,000 volts continuous, is probably at present not to be estimated; on the other hand cables for this voltage are easily procurable. This voltage will cover most transmission work requiring to be done by cable, if higher voltages are necessary the currents will usually be carried by overhead wires or they may be dealt with as a special case, which does not affect this argument. Lastly, in a three-phase circuit, the maximum voltage is rather under $\sqrt{2}$ of the mean. I shall consequently take it that practically there is no appreciable difference in the cost of insulation *per se* whether a certain number of actual volts with continuous current are used or the equivalent—virtual volts alternating, so that for the conveyance of a given amount of energy the amperes are the same in both cases, neglecting self-induction.

Now if we compare a continuous current three-wire system with the middle wire earthed, which is probably the way a large power scheme would be carried out, with a three-phase system with star connections and the centre earthed, and assume that the actual voltage between the outers and the middle wire of the continuous system, and the virtual voltage between any of the three conductors and earth in the three-phase system is the same, there is a good deal of similarity in the two.

On the basis above and assuming the 3rd wire of the continuous circuit as small, the amount of copper needed for the three-phase circuit would only be about 75 per cent. of that needed for the continuous current system, from which it appears that three-phase has considerable advantage. On the other hand, however, with continuous currents, there is a full power factor, while on the three-phase circuit the power factor is only about 80 per cent., so that extra copper must be added to bring the two into strict comparison. When that is done the superiority of three-phase vanishes, in fact the two are as nearly as possible on a par, so that as far as the line is concerned there is little to choose between continuous and three-phase transmission at equivalent voltages.

Further, although the starting torque to be obtained with three-phase currents is not equal to what can be got on a continuous current motor if necessary, it is sufficient for nearly every purpose, so that there is little difference in this respect.

A greater range of speed can be obtained with continuous than with three-phase motors, but it is doubtful if this is an advantage of very serious moment, speaking generally, though it might turn the balance for certain specific applications.

The commutator of the continuous machine has undoubtedly some disadvantage against a three-phase motor, but as the latter must usually have three rings and a short circuiting device, and commutators give very little trouble in well designed machines, this is not a crucial matter.

The point where the two systems differ so far is, however, the fact that three-phase motors can be run direct, and without using transformers at higher voltages than are at present practicable for continuous current machines, and that in manipulating the starting resistances, beyond turning on the main current, these are connected only to the rotor circuit in which the voltage is always moderate instead of being in direct communication with the line, supposing the Continental form of construction to be used.

For this reason three-phase currents are now available, and can be recommended for a certain class of work which seems likely to grow in importance, while, however well theoretically, continuous currents would do the same work, there is no manufacturer to whom one could confidently go to obtain such machines at present.

The question then arises, is the manufacture of continuous current motors for such purposes hopeless, or what is the real position of matters?

As regards the generators, which would always be of very considerable size, there is no doubt in my mind after having seen a good deal of high tension continuous current work and talked with the designers, that generators of 200 kws. and over could be built with safety up to 3,000 volts, and it might also be assumed that no serious trouble would occur with the commutators. American arc lamp machine practice and the results of the Oxford system which is in use at 2,000 volts in two or three places prove this. When, however, we come to moderate sized or small motors, say, down to 5 to 8 units, then we come to a differnt matter, this is where the continuous current system falls behind three-phase, and this will be at the same time a fundamental point in a large number of cases. It must be pointed out that this is not a question of controversy it is a question of facts, which to-day stand as I have stated them. Whether in the future the two systems will always stand related as at present is another question to which it is difficult to give a precise answer, but controversy will not

settle it so far as I can see, it is, in fact, a subject for direct experiment. Great improvements in insulating materials and in our knowledge of the action of high tension currents have been made during the last three or four years; on the other hand but little experimenting has been done by our manufacturing firms in this direction for some time. If the subject were taken up seriously, it is probable that the voltage for working continuous current plant, and particularly motors, might be safely advanced considerably beyond what are considered the usual limits at present, then there would be a still greater parity between the two systems.

What is most important at the present juncture, however, is that apparently there is not much to choose in first cost, in efficiency, or in convenience of working between the two systems, nor does it seem likely that for a long time to come there will be such fundamental differences between the two, either in capital cost, efficiency, or convenience, that it is advisable to put off work which could be well carried out by one or other system according to circumstances, on the chance that further experiment may in the course of 10 or 15 years show that the system passed over would have been slightly better as a system.

EVAPORATIVE CONDENSERS.

Where electricity is manufactured and the cost of fuel forms so large a proportion of the costs of manufacture, the question of condensing is one of greater importance than it is in a textile factory. One thousand horse-power in an electricity works requires but little in the way of wages to keep it going. In a cotton mill one engineer and a couple of firemen would deal with 1,000 H.P., but the mill wages would run into hundreds, so that the engine room wages form a small item. Moreover, from the very nature of the load, the power in a textile factory is more cheaply manufactured than so far it has been for electrical purposes.

To save 10 or 20 per cent. by condensation of exhaust is, therefore, a serious item to the electrical engineer, though one would not think so to judge by the neglect of this means to economy. In this connection the *Practical Engineer* once more draws attention to the evaporative condenser. When water is in plenty, a good vacuum may be secured in many ways. Thus, with an available fall of 32 feet, no air pump need even be applied, but a gravity pipe will serve, and the falling water will carry off air and the condensed steam at as perfect a vacuum as is possible to attain. Having secured condensation by any means, an engine man can, by special attention to glands, joints, &c., save his wages in extra vacuum as compared with "ordinary attention" figures.

Again, ejector condensers, which act on the same principle as the injector, can be used with advantage if the water flows with a head of 15 feet, and they cost less in power than the air pump system. But what our contemporary would more particularly emphasise, is the fact that almost anywhere that a non-condensing engine is at work, the advantages and economy of condensing can be secured with a less total consumption of water than is needed to run non-condensing. It is an error to suppose that a large pond is required to cool the water, or that where water is scarce and space limited it is necessary to work on the high pressure system. This is by no means the case, for condensing working can be secured for less water than non-condensing. In a non-condensing engine all the steam blows to waste. Now, by means of an air condenser or an evaporative condenser, all the steam used by the engine will be saved, but nearly as much will be lost by absorption in the atmosphere from the exposed surfaces of the evaporative condenser. Steam is condensed by robbing it of its latent heat. Water cannot evaporate without rendering as much heat latent as is given off by the same weight of vapour when it condenses. If, then, a pound of steam condenses inside a surface condenser of the evaporative type, it parts with its latent heat. This is absorbed by the water on the outside of the tubes, and this water goes off as vapour fully charged with latent heat.

The condenser is placed as much as possible in the wind, and the air drives off the vapour the more freely, as well as itself carrying off some heat. Also the condenser loses heat by radiation. Thus it is that more steam is condensed than water is lost. Further, seeing that by condensing the power is augmented that may be got from each pound of steam, there is much less steam used by the engine, and the total economy is considerable; so much so, that if at any place the supply of water is just sufficient for non-condensing working, by means of the evaporative condenser we may provide a quiet place with an overflow, and the oil in the steam will float on the surface and run off at the overflow. Our contemporary cites an example where a Ledward condenser is in use for a pair of 26 inches × 5 feet winding engine cylinders, a 28-inch fan engine cylinder, a pair of hauling engines, a pair of donkeys, a belt engine, and a steam lift. The condenser is made up of 800 feet of 5-inch ribbed and corrugated pipes. The air pump is 8 inches × 20 inches by 100 strokes, and it returns all condensed water to the boilers. The water required is from 50 to 70 per cent. of the boiler feed; and this latter, of course, is used over and over again. No trouble arises from grease in the boilers, which have Bowers separators. The first cost is high, but probably less so than a pond; but ponds are out of the question in so many places, even if they had been cheap, that there is no question of comparison. For London, where a roof is available, we cannot understand why so little should be done. Only recently the writer was consulted as to the water supply for a London works, where they wanted 25,000 gallons per hour of water from a well. He recommended a well to give from 4,000 to 5,000 gallons per hour, because in the first place we knew that in London 25,000 gallons cannot be got out of one well, and in the second place it was not required, for what was wanted was an evaporative system or a cooler tower. It is an exceedingly difficult thing to persuade people that they will save by condensing. Then, when they know this, it is as hard to persuade them that they do not require 30 times the boiler feed to condense with. In the case above we failed to do either of these, and the other fellow won who advised three times the expenditure to secure what cannot be got from one well in London.

Comparing the evaporative and ordinary condensers, our contemporary points out that with one there is a lot of water and not much surface, and with the other a very extended surface and little water. Thus it is that an evaporative condenser costs a considerable sum, but when it does this and saves water at 8d. per 1,000 gallons, is it not worth doing it, especially when the use of much water is an incentive to the water companies to be grossly insolent and extortionate?

STONE'S COMPOUND TELEPHONE CONDUCTOR.

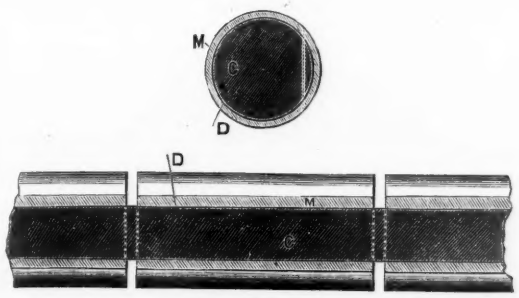
With a view to neutralising the *attenuation* and *distortion* of signals arising from the electrostatic capacity of a submarine cable, Mr. John S. Stone has devised a special type of *compound wire* which he expects will compensate the effect of distributed capacity by means of distributed magnetic induction.

The special features, as described and illustrated in a contemporary, are as follows:—

"The manner of suppressing the evil effects of capacity involves giving the circuit suitable inductance. For the purpose of increasing the inductance of a conductor, Mr. Stone surrounds the wire with a cylinder of paramagnetic material, such as iron, M, figs. 1 and 2; but in order to prevent the current from flowing along the surface of this iron cylinder, the inventor separates the iron cylinder from the copper core, C, by an insulating coating or film, R. The resistance of this coating or film, owing to the longitudinal discontinuities of the sheath, need not be great. In fact, if the longitudinal discontinuities be sufficiently frequent, a mere coating of the oxides of the metals will suffice. Further, in order to prevent the iron sheath from unduly increasing the effective electrostatic capacity of the circuit, and for other reasons, Mr. Stone makes the iron cylinder discontinuous longitudinally."

"The presence of one conductor in the neighbourhood of another necessarily increases the electrostatic capacity of the latter, and to that extent the iron sheath surrounding the copper core increases the electrostatic capacity of the latter; but if the longitudinal sections be sufficiently small, this increase in capacity will be the only resulting increase in capacity experienced. As far as this feature is concerned, it is sufficient to make the longitudinal sections small com-

pared to one-half of the wave length of the electric current transmitted over the circuit. This latter condition is imposed by the fact that if the longitudinal sections of the sheath be as great, or greater, than one-half of the wave length of the electric current to be transmitted over the core, the individual sections of the sheath will have different portions simultaneously subjected to the extreme differences of potential of the positive and negative maxima of the waves, the effect of which on the current would be that of a spurious increase of electrostatic capacity. The other conditions which demand the division of the sheath into relatively short longitudinal sections are relative to the prevention of the current from passing to the surface of the sheath, as already described, and these conditions are therefore closely allied with the insulation between the sheath and the core. In order to prevent the current from passing to the sheath at one end of a section, and returning to the core at the



Figs. 1 and 2.

other end of the section, it is only necessary to make the impedance of the path, *viâ* the sheath, greater than that *viâ* the core. Of course that could be done with scarcely any film of high resistance material between the core and the sheath, if the sections were made sufficiently short."

As to what improvement in speed may be expected from such a compound wire, Mr. Stone, very wisely we think, does not commit himself, as practical results can alone satisfactorily determine that point, and theoretical values are frequently found to differ widely from actual experiment. We may, however, point out that the principle involved in the construction seems at variance with the condition required for accelerating speed, as laid down by Prof. S. Thompson in his excellent paper on submarine telephonic cables, where he says:—"The cable itself must be freed as much as possible from self-induction. '*Never for such a purpose* (enabling the circuit to transmit telephonic signals) *must a cable be constructed as Atlantic cables have hitherto been, of a single conductor* (of stranded copper) *surrounded by an iron sheathing that comes in between the outgoing and returning parts of a circuit, thus adding an enormous impedance.*'"

From a mechanical point of view the *compound wire* would offer certain difficulties in construction. For instance, to cover the conductor with an iron cylinder would be a difficult and expensive operation, more especially as the two metals have to be separated only by an insulating *film*. If the latter, moreover, be supplied by *a mere coating of the oxides of the metals*, it is very questionable whether the resistance would be sufficient to prevent the charge, near to the sending end at least, passing to the iron cylinder. Unless made in very short lengths, the process of covering the copper with the iron would present serious difficulties, and short cylinders would have to be connected together. There is no question that such a compound wire would be very rigid and difficult to coil, and as bends would not readily straighten out, the insulating film would be removed in places when putting on the iron cylinder. The permanent bend which the latter would take on the drum from which the compound wire passes to the gutta-percha covering die, would make it spring, and the insulating coating would consequently be uneven. Even though well heated and compounded before covering, on account of its cylindrical form, the gutta would not adhere as firmly as it does to a copper strand. Some of these objections might be obviated if, instead of a cylinder, iron tape were lapped spirally around the copper conductor, and it certainly would be much easier to insure the insulating film between the iron and copper being more regular and perfect.

The dielectric covering the compound wire should, of course, be shown in the diagram as continuous instead of separated by gaps from adjacent sections like the iron cylinder.

With regard to electrical tests: Imperfect insulation between the copper conductor and its iron envelope would be liable to give variable results when measuring the conductor resistance or capacity, and probably also unsteady readings and uncertain electrification *fall* during insulation tests.

In pointing out what appear to be difficulties, we have no desire to disparage attempts to solve the question of rapid signalling through long submarine cables; on the contrary, we welcome with satisfaction every fresh effort to advance this very important and difficult problem.

THE UTILISATION OF WATER-POWER BY ELECTRIC TRANSMISSION.*

By WILLIAM BAXTER, Jun.

Everyone who is familiar, in a general way, with the operation of electric currents, realises that they afford a means for the transmission of power over great distances at a moderate expense, and therefore believes that eventually, through this agency, every water-power of any magnitude will be made available. There are very few, however, who do not labour under the impression that this phase of electric development is still in the experimental stage. The only work in the line of water-power transmission that has come prominently before the public is that of the Niagara enterprise. This has attracted world-wide attention, owing to the magnitude of the power available, the general belief being that in the course of time the energy supplied from that source will be counted by the hundreds of thousands, if not by the millions, of horse-power. This undertaking is generally looked upon as an experiment, a sort of crucial test, that will determine whether electric transmission can be made successful with our present knowledge of the science, or whether we shall have to wait until some time in the future when, by further development, the barriers that block the way to the attainment of our ends may be removed. Such impressions, however, are entirely wrong; the experimental stage of long-distance power transmission has been passed, and at the present time the manufacture of machinery for this branch of the electrical industry is of as much importance, if not more, than any other branch, and the indications are that in the very near future it will become as important as all the others combined.

It may prove a surprise to many to learn that work in this line has been carried on, more or less extensively, since 1892. In that year one of the large electric manufacturing companies installed about 15,000 horse-power of water-power transmission apparatus. Last year the business of the same concern, in this line, was about 60,000 horse-power.

One of the first installations of magnitude was that of the Hartford Electric Light Company, which was commenced in 1892. The capacity of this plant is over 1,500 horse-power, and the power is transmitted over a distance of about 11 miles. Among the large plants installed since that time may be mentioned one at Sacramento, Cal., which has a capacity of nearly 11,000 horse-power; one at Plezer, S. C., of 7,600 horse-power; Salt Lake City, about 7,000 horse-power; Columbia, S. C., 4,230 horse-power; Bakersfield, Cal., 3,420 horse-power; Montreal, 12,000 horse-power; Ogden, Utah, 11,000 horse-power; Hookset, N. H., 3,000 horse-power; Fresno, Cal., 2,300 horse-power; Portland, Ore., 4,600 horse-power; Minneapolis, Minn., 12,000 horse-power; and several others.

These plants, as will be noticed, are all of large capacity, and represent in the aggregate nearly 80,000 horse-power. There are a great many smaller installations, ranging from 2,000 down to as low as 50 or 60 horse-power, thus showing that this form of power transmission is not limited to large units. The total number of water-power plants now in

* *Scientific American.*

operation, or in process of construction, cannot be ascertained with accuracy, but it is known that there are over 200 light, power, and electric railway stations that depend exclusively upon this source of energy, and many others in which it is used in connection with steam engines. Water-powers, as is well known, are not uniform; the flow of water varies at different periods of the year, and in some instances, the variation between the maximum and the minimum capacity may be as much as 60 or 70 per cent. When the minimum power is sufficient to meet the requirements, a water plant alone is used, but in other cases it is supplemented by a steam plant, the latter being brought into requisition as fast as the water supply falls short. In some cases even the maximum capacity of the water-power is not sufficient to meet the requirements, so that at all periods of the year steam has to be used. In these composite plants the total capacity of the water power at all seasons of the year is fully utilised, and the steam engines are used to supply only the difference between the energy thus obtained and the total amount required.

What has been accomplished so far demonstrates conclusively the feasibility of transmitting power over long distances on a commercially successful basis. At Sacramento, Cal., the distance of transmission is 22 miles; at Fresno, Cal., it is 35 miles; at Ogden, Utah, 36 miles. The distance from Niagara to Buffalo is 21 miles, which is less than the distance in either of the three cases cited; therefore, there can be no doubt as to the success of transmission in the latter case, so far as the engineering features are concerned.

Heretofore there has been some doubt in the minds of engineers as to the practicability of long distance transmission, because it was doubted whether an electrical pressure sufficiently high to reduce the cost of copper in the conducting lines could be used successfully, but it has been shown by the actual operation of the installations already named that there is no difficulty to be encountered in this direction. In a large number of cases the pressure of the line current is 10,000 volts, and in Ogden, Utah, 15,000 will be used. With such pressures, the cost of transmission lines can be reduced to a point well within permissible limits, for distances as great as twenty-five miles, and where the price of fuel is high enough to increase the cost of steam power to a point that will justify a greater loss of energy in the line, the distance can be considerably increased. There is no reason to believe that in a pressure of 10,000 or 15,000 volts we have reached the limit. If this can be handled successfully now, it is more than probable that before long twice as much will be within the possible range, and such an increase in pressure simply means that the 30 and 35 miles over which power is now transmitted will then be increased to 60 or 70 miles.

The future development along the line of water power transmission promises to be very great, from the fact that there is so much power to transmit. According to a section of the United States census of 1880, devoted to the water powers of the United States, the energy of this kind available runs up into the millions of horse-power. Some 50 odd power sites that are described have a combined capacity of over 500,000 horse-power.

The development for some years to come will no doubt be in the direction of utilising large water powers, but eventually, as the cost of apparatus and the installation is reduced, smaller ones will be taken up, and perhaps the day is not far off when every farmer who has a power of 10 or more horse-power on his premises will harness it, and do with it the work now performed by animals or agricultural steam engines.

THE RIVER PLATE TELEGRAPH DISPUTE.

[FROM OUR SPECIAL CORRESPONDENT AT BUENOS AIRES]

The Closing of the River Plate Telegraph Company's Offices in Buenos Aires.

Since this matter has evidently attracted a considerable amount of attention amongst people interested in electrical matters in England, it may be of interest to describe the dispute which has arisen between this company and the Argentine Government from the point of view of the general public on this side of the Atlantic, and also to set forth the aspect of the case as it appears to those who are more intimately acquainted with telegraph matters.

The course of events which led up to the closing of the River Plate Telegraph Company's offices are as follows:—

On July 3rd last year, a resolution, signed by the President of the Republic and by the Minister of the Interior, was published in the *Boletin Oficial* (a Government gazette in which all Government resolutions and notices are published), by which it was enacted that the "Madeira" route could not impose an extra rate, over and above their ordinary charge, on telegrams received in Buenos Aires from the "Galveston" route, and destined for Brazil and beyond.

This resolution was directed against the extra charge of 45 cents gold per word which the "River Plate" Telegraph Company were collecting here, and which was generally understood to be divided between themselves, the "Western and Brazilian," and the "Western Brazilian and Submarine" Telegraph Companies, on all messages received through the "Galveston" route for transit to Brazil and beyond.

On or about July 20th the opinion of the "Procurador de la Nacion," or chief legal adviser to the Government, was published, upholding the President's decision as to the illegality of the charge already referred to.

On August 22nd the *Boletin Oficial* published a further decree confirming the previous resolutions in stronger terms, and from which it appeared that the "River Plate" Telegraph Company had declined to comply with the Government's request to forego the extra charge on through traffic coming *viâ* Galveston, and had suggested that the Galveston Company could send their messages by the overland route if they liked, and further that they, the River Plate Telegraph Company, could not in any case reduce the rate since it was enforced by the "Western and Brazilian" and the "Western Brazilian and Submarine" telegraph companies, with whose business they had nothing to do, and for whom they were only acting as collectors.

This explanation the Government refused to accept, and insisted that since the charge complained of was an illegal charge it must not be exacted, and that if the River Plate Telegraph Company continued to collect it the Government would find means of forcibly preventing them.

On October 29th a further decree was issued by the Government, once more confirming the previous ones and emphasising their determination to abolish the extra charge of which they had so often complained.

After this no further official publication referring to the matter appeared, but from time to time the Argentine newspapers were much occupied with it, and judging from their comments it was clear that the Government were getting more and more annoyed at the persistent refusal of the "River Plate" Telegraph Company to comply with their decrees, and at the arrogant and uncompromising tone which it was alleged characterised the communications they received from the company in question.

On January 30th, 1897, more than six months after the Government had issued their first decree calling upon the "River Plate" Telegraph Company to discontinue the extra rate, the public were surprised by the announcement that the offices of this company in Buenos Aires had been closed by order of the Director-General of Posts and Telegraphs, acting under the instructions of the Government.

The publication of this news was received with shrieks by the local English press, which demanded that Her Majesty's Minister should interfere, and should insist upon the reopening of the company's offices, without appearing to concern themselves with the question of whether the Argentine Government were, or were not, justified in the step that had been taken.

The feeling of most Englishmen, and, indeed, of most foreigners out here, was very much the same as that of the press; they knew that a foreign telegraph company had been obliged to close its doors and to suspend its business on account of the action of the Argentine Government, and they thought they recognised a very arbitrary and unjust use of the power of the Government, forgetting, or being ignorant, of the fact that for more than six months the Government had endeavoured to persuade the "River Plate" Telegraph Company to comply with their decree, and that the decree which they had issued was fully sanctioned by the

International Telegraph Convention, on whose regulations the "River Plate" Telegraph Company were, and had been for a long time, infringing.

When the "River Plate" Telegraph Company found that the Government were determined to keep their offices closed until they undertook to abandon the extra charge already referred to, instead of availing themselves of the Arbitration Clause in Art. 6 Chap. 1 of the Argentine law dealing with this question, and which fully provides for such a contingency as had arisen, they instituted legal proceedings against the Director-General of Posts and Telegraphs, by whose immediate orders their offices were closed; but this action could not be maintained, the Court declaring that they had no case against the Director-General, and that they must proceed directly against the Government under whose orders the Director-General had acted when he gave instructions for their offices to be closed. It is understood that the company have appealed from this decision and the result of their appeal is not yet known, but it is expected that the decision of the lower court will be confirmed; in which case, if the company wish to persist in their legal course they will have no alternative but must bring their action directly against the Government. This, however, cannot be done until they have obtained the sanction of the legislative assembly to such a course, and since Congress is not now sitting an application for leave to bring such an action cannot be considered for some months, during which period, and also during the course of the subsequent trial, supposing the application for leave to bring an action is successful, the offices of the company will remain closed.

Meanwhile the local English press are talking of an indemnity which they imagine the Government will eventually have to pay, and are calling attention to what they consider the unjustifiable behaviour of the Government in closing the offices, and putting a complete stop to the business of an English commercial company for no other reason than that they were continuing to enforce a charge which this same Government had arbitrarily declared to be an illegal and unfair charge, or, in other words, they assert that the Government have taken upon themselves to determine, and to enforce their determination with the utmost severity, at what price an English company, trading in this country, is to perform certain work, the cost of which the Argentine Government knew nothing whatever about, towards the performance of which they have contributed nothing, and the whole plant for carrying out which, with the exception of one small receiving station, is situated outside the Argentine Republic; going on to point out that the significance of so new and so high handed a departure from ordinary custom on the part of the Government of the Republic will not be lost upon any foreigners engaged in trade in this country, and will not encourage British or other foreign capitalists to invest their money in a country where the ordinary course of business is interfered with in so unwarrantable a manner.

It does not seem to be generally known here that the "River Plate" Telegraph Company, by charging a different rate for messages received *viâ* Galveston for transit to Brazil and beyond, to that which they charge for messages originating in Buenos Aires, have most emphatically transgressed Article 10 of the International Telegraph Convention, and that by Article 9 of the same Convention, as well as by their own special statutes, the Government of the Argentine Republic are fully authorised to act as they have in the matter; and that in place of having acted hastily, they allowed the matter to be under discussion for more than six months before taking any action whatever.

OCEAN DEPTHS.

In a leading article in our trans-Atlantic contemporary, the *Electrical Engineer*, a few weeks ago, we note that "In the case of the Pacific cable there was until recently some doubt as to its earning capacity." Further, that "the rapid development of political changes in the Far East, with concurrent commercial advances, have shown at once that a cable there ought to be, and that it would pay." Further, the writer says: "Next, however, to the question of earning a profit . . . . is the problem of laying the cable successfully."

There has not been any doubt in the minds of business men for many years past, either in Canada or England, as to the earning capacity of a cable system across the Pacific, but the interests of a powerful combination of telegraph companies controlling the network of cable and landlines now serving the needs of practically the whole civilised world, have been made the most of to create those doubts, now happily dispelled.

As to the "problem of laying the cable successfully," this has also been solved in theory by practical engineers on both sides of the Atlantic, and it is in regard to this same question that we must take exception to the remarks contained in the latter portion of our esteemed contemporary's article.

Let us review first of all the "serious difficulties," the nature and variety of "which have often been alluded to in our pages." Chiefly, "the extreme lengths between landing places," and "the enormous depths." Certainly there is an abundance of cold water in the Pacific, and some of it is evidently wanted to throw over the project; but seriously now, why should a journal with any pretension to up-to-date technical knowledge make such an assertion as this? "The importance . . . . comes in when dealing with a cable route like that of the Pacific, which is a good round 7,000 nautical miles, while an Atlantic cable is one-third that length." The wording is vague, but the casual reader would infer that 7,000 nautical miles was the length of one section, instead of being somewhere about the length of the entire system.

The longest section of cable would really be about 3,500 nautical miles. A working speed of 15 or 18 words per minute, dependent upon the weight of the copper conductor and its insulating sheath, could be attained easily over this section.

Regarding the depths in the Atlantic and Pacific, our contemporary is not so much out of his reckoning; but why use the statute mile as a measurement in stating deep sea soundings? It would be more correct to state this information in nautical miles, or better still, in fathoms.

In drawing a comparison between the Atlantic and the Pacific for cable purposes, it will be found that the former runs the latter pretty closely in the matter of depth. Between Bermuda and Porto Rico, for example, on a line of soundings, there are depths of from 2,875 fathoms near Bermuda, to 3,875 fathoms near to Porto Rico. The deepest sounding in the Atlantic yet discovered is in close proximity to this latter island, where the depth encountered is 4,561 fathoms, and not 4,620 fathoms, as our contemporary believes. Another line of soundings, from Porto Rico towards Charleston, U.S., shows depths of from 2,990 fathoms to 3,133 fathoms. There are soundings between Africa and the West Indies of 2,500 fathoms to over 3,000 fathoms. Yet this would not deter the Spanish Government from laying a cable to Cuba if they possessed the funds necessary.

In the South Atlantic, between Ascension Island and the River Plate, is a line of soundings with over 3,000 fathoms at the deepest part.

In the Pacific the deepest soundings recently found were by H.M.S. *Penguin*, to the N.E. of New Zealand, and eastward of a line, thence to the Fiji group, viz., 5,155 fathoms, 5,147 fathoms, and 5,022 fathoms. These depths lie outside the track of a cable. A line between New Zealand and Fiji is thick with soundings which show 2,500 fathoms as the average depth.

Between the coast of California and the Sandwich Islands soundings are abundant, and show invariably not more than 3,000 fathoms at the deepest.

Soundings midway between Vancouver and the Sandwich group show 2,800 fathoms and 3,115 fathoms. South of this, close to, is the plateau between California and the Sandwich Islands, which is well sounded over, and shows at the deepest not more than 3,000 fathoms. North of the 3,115 fathom position above referred to, the depth shoals to 1,500 fathoms on a gentle incline, closing in with the coast gradually, on a line along which a cable would be laid.

Between the Sandwich group and Japan there are depths of over 3,000 fathoms, and near to the coast of Japan several of over 4,000 fathoms, including one of 4,643 fathoms, found by the U.S.S. *Tuscarora*. These are deep furrows or gorges, which would naturally be avoided in laying cables. All the other abnormally great depths in the Pacific appear to be in

isolated positions, and are by no means generally met with.

Admiral Wharton, the Hydrographer to the Admiralty, in a letter to the *Times* of February 29th, 1896, refers to the deep soundings recently found by H.M.S. *Penguin*, and says:—"These soundings are separated by water much less deep, and the bottoms may not 'be connected.'" The gallant admiral goes on to say, "These soundings afford additional evidence of the observed fact that the deepest holes are not in the centres of the oceans, but are near land."

One of the deepest Atlantic cables lies in 2,850 fathoms, or, to put in the terms our contemporary uses, nearly $3\frac{1}{4}$ statute miles. No great difficulty seems to have been experienced during laying.

The physical configuration of the basins of the Atlantic and the Pacific differ materially; the Atlantic basin is long and narrow in comparison, forming two long sinuous troughs separated in the centre by a ridge known as the Dolphin.

To quote Dr. Mill:—"The Pacific basin is far more vast, and forms one grand hollow from 60° N. to 60° S. latitude, and between the Western edge of the Western World Ridge, and the Eastern edge of the Eastern World Ridge."

Our contemporary asserts that "the Pacific bed appears susceptible in a noteworthy degree to submarine volcanic disturbances, tending to destroy or modify a cable bed suitable for other reasons." There is a delightful vagueness about this extract from the article, which we shall not attempt to fathom, or statute mile, but we do venture to differ from our friends on their conclusion relating to submarine volcanic disturbance.

A study of Plate II., page 92, in "The Realm of Nature," by Dr. H. R. Mill, will show that the Atlantic Ocean, from within the Arctic circle to the Cape of Good Hope, comprising the whole region of the mid-Atlantic, is subject to earthquake shocks, whereas the earthquake region in the Pacific is confined to the western shores of the American Continent, from Alaska to Cape Horn, and to the islands which lie in festoon along the Asiatic Continent. Earthquakes are frequent in the Andes; less so on the plateau of Central America, along the coast ranges of North America, and in the Aleutian Islands. The intervals become less and less along the shores of Asia, and arrive at a maximum in the Malay Archipelago.

The active volcanoes at the Sandwich, Society Islands, and other groups in the Pacific, would appear to serve as safety valves. This is apparently in accord with Dr. Mill's views as the great expanse of the Pacific Ocean is not mapped out by him as an earthquake region. The volcanic line in the Atlantic takes in Iceland, the British Islands, the west coast of Spain and Portugal, the Azores, Madeira, the Canary Islands, the Cape Verde Islands and Ascension, &c., thus setting up a source of disturbance right along the centre of the ocean. As a contrast, in the Pacific the lines of disturbance encircle this ocean, and form, as poetically described by Dr. Mill, "a ring of fire around it." Prof. Milne points out that most shocks originate along the lower part of the slopes of the World Ridges. We know that the whole seaboard from Northern California to the South of Chili is subject to earthquake shocks of greater or less intensity, yet the recorded breaks to any of the numerous lines of cable that extend along that coast have, but very rarely indeed, been ascribed to earthquake disturbance, and even in such case the assumption has been by no means certain.

We should have thought that our friends across the Atlantic would have been better posted than to say that the "deep water in the Pacific is much colder than that in the Atlantic. In reply, we will quote some bottom and surface temperatures from the *Challenger's* report. In the vicinity of Fiji, 2,440 fathoms. Red clay. Bottom T 35·8° F. Surface 80°, 2,450 fathoms. Red clay. Bottom T 36°. Surface 80°, off Japan, 2,675 fathoms. Blue mud. Bottom T 35·8°. Surface 69·5°, 4,475 fathoms. Radiolarian ooze. Bottom T 35·2°. Surface 80 2°. Between Yokohama and the Sandwich Islands in 3,950 fathoms. Red clay. Bottom T 35° F. Surface 70·5° F., and the Sandwich Islands to Tahiti in 2,925 fathoms. Glob. ooze. Bottom T 34·6° F. Surface 79·5° F.

Here also are some bottom temperatures in the Atlantic. Between Teneriffe and Sombrero Island, in depth 3,000 fathoms. Red clay. Bottom temp. T 35·5° F. Surface 75°. Depth 3,150 fathoms. Red clay. Bot. temp. 36·8° F. Surface 69°. Between Bermuda and Halifax, in depth 2,850 fathoms. Red clay. Bot. temp. 36·5° F. Surface 65°. Between Bermuda and the Azores, in depth 2,850 fathoms. Bot. temp. 36·2°. Surface 71·5°.

The decrease of the bottom temperatures in depth greater than 3,000 fathoms, is therefore shown to be inappreciable.

The increase of pressure due to the "enormous depth," having "its influence on the type of cable adapted to withstand the strain," is another ambiguous piece of verbiage; but, as in the case of the decrease of temperature in great depths, the effects of increase of pressure would not make any appreciable impression upon a well constructed, light, armoured type of deep sea cable. With regard to the pressure, taking the weight of a column of sea water 1 fathom in height and 1 square inch in section as = 42·768 ounces, there would be registered at 1,000 fathoms nearly 1·2 ton to the square inch, and at 3,300 fathoms = 3·9 tons to the square inch, which would be the maximum met with on possible routes for the Pacific cables.

The fact of living organisms being sufficiently protected by natural armour against pressure at such a depth as 2,850 fathoms (Wyville Thompson) *vide Challenger* report, the Scalpellum Regina, should do away with all doubts in this direction. Even the delicate, minute shells of Foraminifera that find a resting place in the ooze at great depths remain uninjured during ages under the enormous pressure.

Bottom specimens, on being subjected to microscopical examination, reveal in most perfect forms the shells or coverings of marine animal life. These forms have been preserved intact during the life of the world in the soft ooze, the products of their accumulation, which has served as an undisturbed resting place for countless generations. This accumulation of the remains of minute organisms increase with increasing depth, and it may be taken as an axiom the statement made by the President at the Electrical Engineers Institution in his address, that "The deeper the water the better the bottom, the safer the cable."

HOW AND WHAT TO STUDY.*

By Prof. CHAS. H BENJAMIN.

I have been asked to write something concerning the studies a young mechanic may pursue while he is at work at his trade. As soon as I attempt to write about this, I see in memory a young fellow of 18 or thereabouts, bending over a drawing-board, copying by the dim light of a kerosene lamp, odd, Englishy-looking lathes and engines from Cassell's Mechanical Drawing, his pencil point breaking now and then and his line pen spluttering from the heavy pressure of fingers better used to hammer and cold-chisel. He did go to sleep over the drawing occasionally, but he would awake again and struggle on until the plate was finished, and in time he learned to draw after a fashion.

He studied mathematics in much the same way, and ever since that time he has appreciated the difficulties and discouragements of evening work coming after a day of toil. To-day the opportunities for self-improvement and self-instruction are much better than they were then, as a glance at the columns of this paper will show.

In the first place it *does pay* to study if you study in the right direction.

A true understanding of the principles of mechanics and machine design will make you more independent and worth more to your employers in dollars and cents, a fact they will not be slow to recognise.

If you are an apprentice or a young journeyman and want to study, try and find some mate of yours who feels the same, and arrange to study together. You will help to keep each other awake in the long winter evenings, and one light will do for both. Understand at the outset that you cannot learn much about mechanics without studying mathematics at the same time.

If you can attend some evening school in mathematics one or two evenings a week, so much the better; it will be a break in the monotony of your evening work. You must

* *American Machinery.*

make up your mind to devote at least four evenings a week to study, if you would accomplish much. Even five evenings of two hours each are not too much for a young man in vigorous health.

Life is short, and what you mean to do must be done while you are young. Now this study which we are to talk about is not amusement; it is hard work, and all the harder because you are tired physically and feel more like smoking and reading the evening paper. It will take plenty of pluck and endurance to get learning in this way, and if you are not plucky, but rather lazy and indifferent, just let it alone and stick to your dollar and a half a day, which in such a case is rather more than you are probably worth.

Some will advise you to study algebra and geometry before you attempt anything in the way of mechanics. If you do this, I am afraid you will be discouraged before you get to mechanics, because you will not see the use of it all.

An old friend of mine, a good mechanical engineer, entirely self-educated, once told me that he proceeded in this way: He got some book bearing on his particular work, and began to study it. He soon came to some mathematical formula that he could not understand. He then bought an algebra, studied that far enough to supply his need, and began again on his first work. Perhaps a geometrical demonstration puzzled him; he bought a geometry and studied that. So on, until when I knew him he was well versed in all the higher mathematics as well as in mechanics. This may seem like trying to put the cart before the horse, but the method has this one great advantage, that the learner knows at all times what he is after; he does not study algebra until he knows why he needs algebra and the $x^2 + y^2$ has some meaning to him.

We will assume that you have a good common-school knowledge of arithmetic; if you have not, you may study shop arithmetic from the last volume of this paper. First get a copy of some good work on elementary mechanism, such as Stahl and Wood's, and begin to read it. Do not be alarmed at a Greek letter now and then, as they are perfectly harmless, and you may call them anything you please. Get a copy of Wentworth's "School Algebra," and also copies of "Plane Geometry and Plane Trigonometry," by the same author. There may be other text books just as good, but I can recommend these from experience.

Learn from the algebra at first the use of simple equations and how to add, subtract, multiply, and divide with letters instead of figures. Do not try to work all the examples, but just a few under each head.

In geometry study Book I. on lines, angles and triangles. In trigonometry try to learn what is meant by sine, cosine and tangent, and study the right triangle, working a few examples; 18 or 20 pages of the text-book will be all you will need at first. All this time I would be reading the mechanism regularly. When you come to something that you do not understand, mark it and pass on, and you will gradually begin to realise what you want of mathematics.

We will suppose that you are reading mechanism two evenings a week, and studying mathematics the remainder of the time. As soon as you learn what an equation is in algebra, look up the equations in the mechanism and see how many of them you can understand and solve. If in the mechanism you find the expressions "sine" and "tangent," refer to your trigonometry and find what they mean. If you learn about similar triangles in geometry, try and find such problems in mechanism, and see how the principles are used. In short, refer from mathematics to mechanics and back to mathematics again, making one illustrate and help explain the other, and remembering all the while that the mechanics is what you are after, and that mathematics is to be used only as far as it helps you.

Look about you in the shop and see what you can find of levers and cranks, gears and cams, to illustrate the principles laid down in the book. If you see a movement that interests you, try and find it in the text-book, or at least something like it. At first you may find it dull work, but as you begin to get a glimmering of what it is all about, you will get new courage and interest, and after that the road will grow easier every day. When you have mastered the mechanism and the mathematics which that implies, you will have made a good start on the high road to a mechanical education.

Now if you will buy a little book entitled "Lessons on Applied Mechanics," by Cotterill and Slade, and work through it carefully, doing all the examples that you can and brushing up your mathematics as you go along, you will have acquired a fair elementary knowledge of the principles of mechanics which will enable you to solve nearly all practical problems that present themselves. I have so far said nothing about drawing, for I do not think it of much use to learn that until you know what you want of it. All this time that you have been studying mechanism, you should have had a sketch book or pad of notepaper, and made free hand sketches of mechanical movements which interested you, and of various machine details. You should accustom yourself to use drawing as a means of expressing ideas, just as you use written words, so that it becomes a second nature to you to sketch anything you wish to remember or describe. If you work from blue prints in the shop, or if you can borrow some to study, this will help you to understand how a drawing is made. You can get some drawing instruments at any time and begin to practice on drawing straight lines and circles, so as to become familiar with the instruments. Anthony's text-books on elementary drawing and on machine drawing are excellent works for the beginner. And here it will be of great benefit to you if you can attend an evening drawing school for one night in the week at least.

When you have become sufficiently familiar with the principles of drawing, the book on mechanism will tell you how to draw gear teeth and cams, and how to design various link motions. Make up your own problems from what you see in the shop, and simply add a little common sense to what you learn from your book in working them out. Brown & Sharpe's "Practical Treatise on Gearing" is a good book for the machinist and pattern-maker to have. Try and make your drawing, however, a means to an end, and not the principal thing. Let me repeat, it is of little use to be able to make a nice drawing unless you know what to draw and why.

The motive for this study may be summed up as follows: You see many things in machinery which you do not understand. You wish to understand them. Mechanism and applied mechanics tell the reasons of these things. Mathematics is simply a convenient tool with which to work the problems. Drawing is another convenient tool as an aid in expressing to others the ideas which you wish to convey.

But in all cases the problems and the ideas come from your every-day work, and that which is around you, and your success will depend upon the close connection which you keep at all times between your acquired knowledge and your practical work.

THE OPENING DAY OF THE BRUSSELS INTERNATIONAL EXHIBITION.

One early morning last week from all parts near Brussels was seen every kind of vehicle making its way towards the Park Cinquantenaire.

At the hour of one the firing of a small cannon in the gardens and park was the only official sign to mark the opening of the Brussels International Exhibition.

The public were very quietly admitted, which was well, for what more farcical than ceremony or display to herald the admittance of the public to a labyrinth of huge packing cases and partly built courts. It seems to us deplorable that the executive committee should not have exhibited more energy to bring the exhibition to what we might call a reasonably advanced stage by the advertised day of opening.

After passing through the French section we reached the British, and were struck by the bright display of bunting, which gives this section the appearance of a man-of-war dressed for a reception. The decorations had not been controlled by any sole authority, and are, consequently, not marked by uniformity or the sameness of their neighbours.

One of the attractions to the Belgians, and, we think, the greatest, was the sight of some of our Royal Naval Reserve men and City police.

Nearly all the leading British firms are in evidence, such as: Dewar & Sons, W. D. & H. O. Wills, Waterlow Bros. and Leyton, J. & J. Coleman, Price's Patent Candle Company, W. T. Glover & Co., Mappin & Webb, Oetzmann and Co., and several of the large railway and steamship companies.

So great was the crowd drawn by the attractive models, that it was difficult to get near the show cases.

Messrs. North & Co, Ltd., have sent a fine block of their renowned Welsh steam coal, while the exhibits of manufactured iron and steel sent by the Cleveland Iron Master's Association, the Tees Iron Works, the N. E. Steel Company, and the Consett Iron Works, will prove of very great advantage to those interested in this trade.

We must express the fact that the English section is very much more advanced than the others. The public had practically no other section to visit, and, consequently, the passages were crowded all day.

We were struck by the picturesque group of kiosks, mosques, and chatels mostly devoted to restaurant purposes. The exhibition was disordered and unprepared to the last degree, but we have no doubt that success may be predicted, though we feel sure that more than a month must pass before the official ceremony can justifiably take place.

THE DISCHARGE OF CONDUCTORS IN CIRCUIT WITH VARIABLE CAPACITY, RESISTANCE, AND SELF-INDUCTION.

There appears in *Comptes Rendus* (cxxiv., p. 452) an article by M. Pétrovitch, in which he considers the discharge of circuits containing variable capacity, resistance, and self-induction.

Let C = the capacity of a conductor.
r = resistance of circuit.
L = self-induction of circuit.
Q = the charge on the conductor.

It is known that the equation for the quantity of electricity at any instant is

$$\frac{d}{dt}(L\,i) + r\,i + \frac{Q}{C} = 0 \qquad (1)$$

i being the instantaneous value of the discharge current.

If L, r, and C are constant the nature of the discharge is dependent on the sign of the expression

$$\frac{r^2}{4\,L} - \frac{1}{C}.$$

If this expression is positive the discharge is continuous, and, if negative, it is oscillatory.

If L, r, and C are variable the equation becomes

$$L\frac{d\,i}{d\,t} + \left(r + \frac{d\,L}{d\,t}\right) i + \frac{Q}{C} = 0,$$

or, remembering that $i = \frac{d\,Q}{d\,t}$,

$$L\frac{d^2\,Q}{d\,t^2} + \left(r + \frac{d\,L}{d\,t}\right)\frac{d\,Q}{d\,t} + \frac{Q}{C} = 0 \qquad (2)$$

which is a linear differential equation of the second order with variable coefficients.

If we change the variable Q in this equation by putting

$$Q = \frac{1}{\sqrt{L}} \cdot \gamma\, e^{-\frac{1}{2}\int \frac{R}{L} d\,t}$$

equation (2) becomes

$$\frac{d^2\,\gamma}{d\,t^2} + F(t)\,\gamma = 0$$

where

$$F(t) = \frac{1}{C\,L} - \frac{1}{2}\frac{d}{d\,t}\left(\frac{r}{L} + \frac{d}{d\,t}\log L\right) - \frac{1}{4}\left(\frac{r}{L} + \frac{d}{d\,t}\log L\right)^2 \qquad (3)$$

If $F(t)$ is always positive the discharge is therefore oscillatory, so that *whether* L, r *and* C *are constant or variable* the condition that the discharge should be oscillatory is that the value of $F(t)$ given by (3) should be positive.

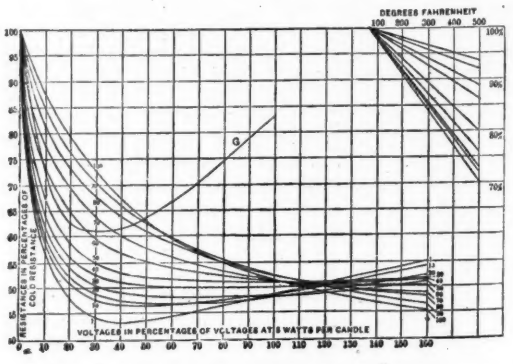
If during the discharge $F(t)$ becomes negative, the oscillations cease and the remainder of the discharge is continuous.

For the whole discharge to be continuous, it is necessary and sufficient for $F(t)$ to be negative throughout the discharge.

CONDUCTIVITY OF INCANDESCENT CARBON FILAMENTS AND THE SPACE SURROUNDING THEM.

An interesting and suggestive paper was read before the American Institute of Electrical Engineering on February 17th by Mr. J. W. Howell. The first part deals with some experiments relating to the specific resistance of various carbon filaments, both treated and untreated, at different temperatures; the second part deals with what is known as the "Edison effect."

Prof. Anthony has drawn attention to the fact that with certain lamp filaments the resistance commences to increase after a certain temperature has been reached as the current is increased, whilst with others, under the same conditions, the resistance continues to fall; but to what cause these differences were due he was unable to explain. This problem Mr. Howell has lately attacked, and his experiments throw much light on the subject. A number of similar untreated filaments were selected and "treated" or "flashed," so that their resistances cold were 90, 80, 70, 60, 50, 40, 30, 20 and 10 per cent. of their original cold resistance. These were then made into lamps. The lamp made with the untreated carbon continued to fall in resistance right up to the point at which it was dared to run it. The slightly treated filaments fell more rapidly in resistance at first, and less rapidly after full incandescence had been reached than the untreated carbon; and this tendency continues until 50 per cent. treatment is reached. With this amount of treatment after the incandescence has attained about 3·5 watts per candle, the resistance remains practically constant as the temperature is further raised. With filaments exceeding 50 per cent. treatment, the resistance, after falling to a certain point, commences to increase as the temperature rises, until with the 90 per cent. treated filament, which is nearly all deposited carbon, the rise from the lowest point to the last at which it was run amounted to 25 per cent. The experiment was made of heating these same filaments in an oven heated to different degrees up to 500° F. They were now observed to fall in the same order as they did when electrically heated, thus proving that the different resistances indicated were due to temperature alone and not to anything else. This result



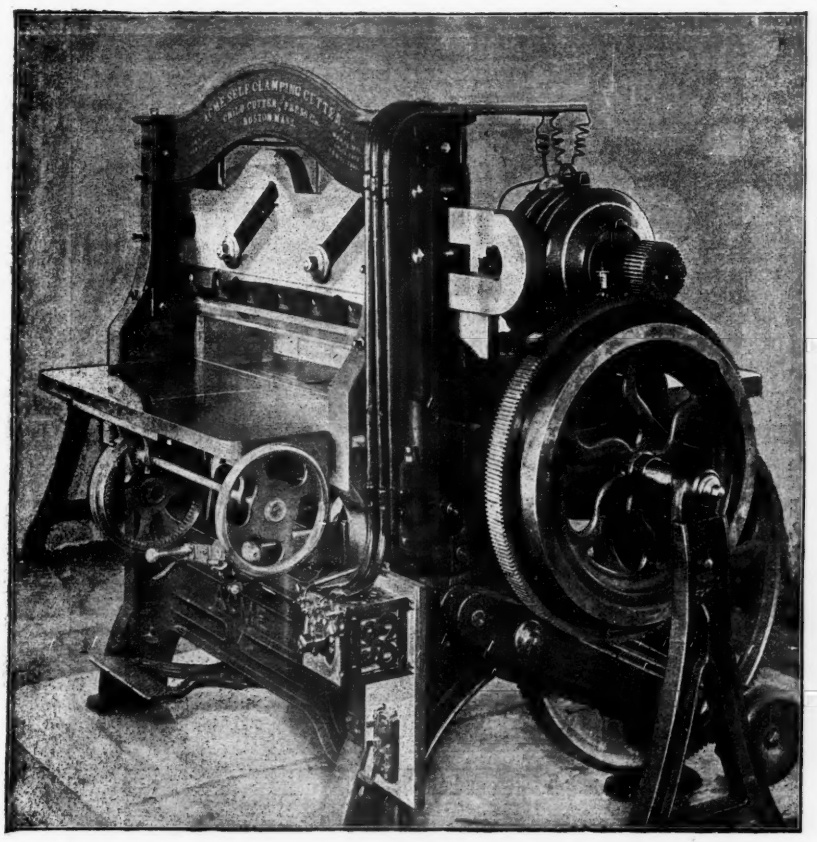
Curves Showing Changes of Resistance of Lamp Filaments with Voltage and Temperature.

is shown in the corner of the figure of the above curves. Untreated filaments, whether they be made from bamboo, cotton, squirted cellulose, tamadine, silk or paper, all fall in resistance in the same proportion as the temperature is raised. Mr. Howell next secured a lamp containing a conductor made of graphite, which Mr. Edison had had made for him in his early experiments with lamps. This carbon, after the first fall, began to rise very considerably in resistance as the temperature was raised. The graphite conductor was not regularly incandescent, so that it is probable the more heated portions had begun to rise in resistance before the cooler portions had fallen to their lowest point. The curve shown in the figure would otherwise probably have fallen to a lower point before

commencing to rise. Mr. Howell concludes from these experiments that the carbon deposited from gasoline vapour is graphite.

It would be interesting to ascertain whether the carbon deposited from other vapours, and under varied conditions of temperature, pressure, &c., exhibits an equal increase in resistance with a corresponding rise in temperature with that obtained from gasoline. The conditions under which carbon is deposited greatly affect many of its physical properties, and this one of different specific resistance at different temperatures is likely to be considerably affected.

The "Edison effect" has now been studied by several investigators, the last important contribution on the subject having been made by Prof. Fleming at the Physical Society last year. An abstract of that paper was published in our issue for April 10th, 1896. Mr. Howell's present communication deals principally with experiments and observations connected with the blue haze so familiar to lamp makers, and he has made several striking experiments. Mr. Preece has observed that the Edison effect is more marked in lamps which show a blue haze, and Prof. Fleming has noted a stronger effect when the vacuum is comparatively poor, but this branch of the subject has not been much studied.



Guillotine Paper Cutter driven direct by a "Lundell" Two-Pole Motor.

If a direct current, about 20 to 30 per cent. more than the normal, be passed through a lamp and the vacuous space shows a blue glow, the positive joint of the filament and wire becomes red hot whilst the negative joint remains cool, the latter becoming covered with carbon soot if there is much blue. This well-known phenomenon Mr. Howell attributes to the chief resistance to the current traversing vacuous space occurring at the surface of the positive electrode, the soot being regarded as proof of electrolysis of residual hydrocarbon gas in the lamp. If an alternating current is used both joints become equally heated. The blue glow in lamps ceases after running them for some time, and lamps having a residual of bromine vapour show no blue at all. Lamps run at high incandescence show a current of ·04 or ·05 ampere more when there is blue colour visible than when it is absent. If the current is gradually increased in a lamp which shows blue the positive joint will get hotter and hotter until the platinum wire fuses. Sometimes only the positive wire fuses and sometimes the resistance falls so low that both wires fuse and what is called "arcing" occurs. To fuse the positive wire alone, from 1 to 5 amperes has been found to pass at the moment of rupture, whilst when both wires have fused 10 to 25 amperes may pass. A lamp, containing a platinum wire sealed into it, was run until a good blue effect was started and the positive joint had become red hot. At this point the positive wire was connected to the outer end of the free terminal. The latter now became heated and the joint became cool, and on increasing the current the end of the platinum wire fused. A lamp was next made with a strip of sheet copper about 1 inch long by $\frac{1}{4}$ inch wide. On connecting this plate with the positive wire, with an ammeter in circuit, and then gradually raising the current, the copper plate became hotter and hotter until it fused. The ammeter "indicated over 5 amperes flowing through vacuous space between the negative leg of the filament and the copper plate."

The question arises, does this current flowing across vacuous space travel in straight lines, or will it go round an obstacle by a circuitous path? To determine this a lamp was made with a glass plate placed between the legs of the filament. The incandescence had to be raised very high in this case before the blue haze became apparent. It then appeared suddenly instead of gradually as is usual, in great abundance, the positive joint becoming red hot, so that it was necessary to reduce the current to prevent fusion of the wire. Instead of disappearing suddenly at the reduced temperature the blue became gradually less, showing that once the path for the molecules has started, the current will continue to flow. But if the blue should disappear and the vacuous current become interrupted, it is necessary to again raise the filament to high incandescence in order to start the flow afresh. Another lamp was constructed with a platinum screen in the place of a glass one, and with an additional platinum wire bent so as to lie between the platinum plate and one leg of the filament. When this lamp was run at $2\frac{1}{2}$ watts per candle-power no blue was apparent, but on connecting the wire terminal with the positive wire and then breaking the circuit, blue immediately appeared at the positive wire and in the bulb. In order to start the vacuous current it is sufficient to touch the wire terminal with one finger and the positive wire with another.

Lamps containing a residual atmosphere of bromine gave unusual results. One which contained enough bromine to depress the barometric column $\frac{1}{20}$th inch showed no Edison effect even when run up to 170 volts, the lamp being one of 110 volts. A second lamp in which the vacuum was more complete showed a slight current when first tried. At 120 volts the deflection on the galvanometer used was 14 divisions, at 128 volts the reading was only 12 divisions, and at 146 volts it was 16 divisions. Observations were made on several days, the effects being less and less each time until at length they ceased altogether.*

* The feeble indication of vacuous current in a residual atmosphere of bromine is very significant, and it would seem highly probable that the current observed in ordinary lamps is in a large measure due to the presence of metallic vapours. It is within the writer's experience that filaments which happen accidentally to contain small quantities

Mr. Howell's concluding remarks are as follows:—

"We have seen that the negatively-charged molecules liberate considerable energy on coming in contact with a body that conveys away their charge. We have also seen that when the blue glow is present there is a considerable flow of charged molecules through the vacuous space, and that the naturally rectilineal movements of these molecules are disturbed.

"We also know that molecules are emitted from the positive leg about as plentifully as from the negative leg, although these molecules do not carry a positive charge.

"The conclusion seems to be that the blue glow is a manifestation of the energy developed by the meeting of the charged molecules with other molecules which take away part or all of their charge.

"Well exhausted incandescent lamps which have burned a long time show a black deposit on the inner surface of the bulb. In lamps with thick, stiff, single-loop filaments, in which the two legs lie in the same plane, a light line may be observed in the black deposit, which is caused by the shielding of this line by one leg, from the molecules emitted by the other leg. This line shows with about equal clearness opposite both legs, indicating that carbon molecules are constantly emitted from both legs, equally and in straight lines.

"In lamps [which have been imperfectly exhausted, the black deposit sometimes appears in patches, symmetrically placed with reference to the carbon. I regard these figured discolorations as indications of disturbances in the rectilineal paths of the molecules, and of the influence of the magnetic field upon the disturbed molecules.

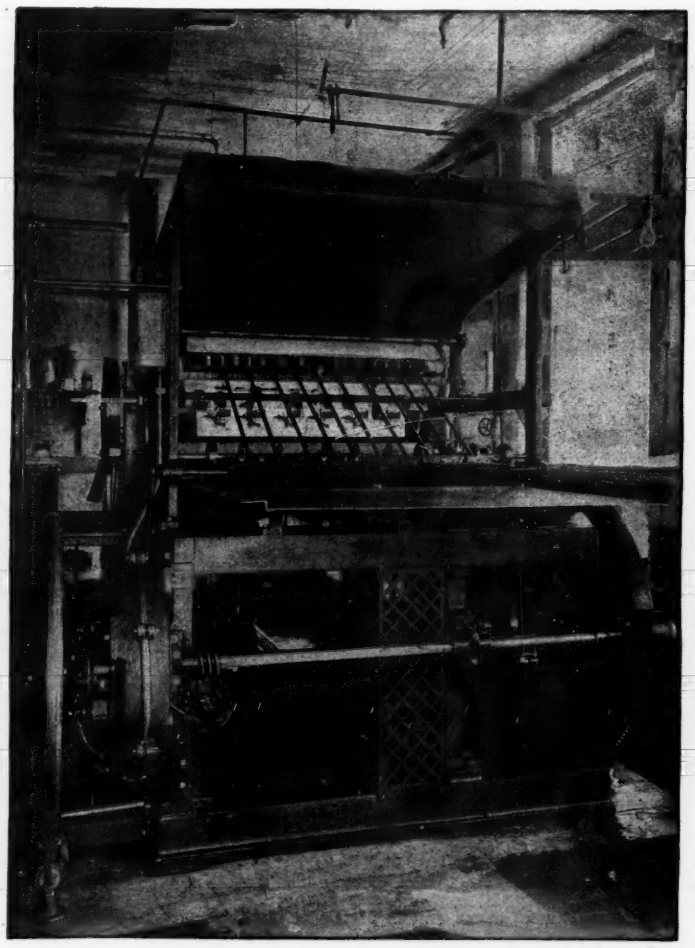
"The activity of the molecules carrying current across the vacuous space seems to depend more on the temperature of the filament than on the potential difference between the legs, 40-volt lamps showing about as strong effects as 140-volt lamps. The energy they exhibit in one direction seems to be very much greater than we would expect from molecules actuated by a potential difference of only 40 to 50 volts. The action of these molecules in carrying electricity in one direction only, may be an indication of the nature of the action between molecules in solid conductors carrying currents, rather than an illustration of the action of statically charged molecules."

of sodium salts, when made into lamps, exhibit an excessive tendency to produce blue haze and arcing across the terminals, and these results likewise occur when iron is present. It is doubtless for the same reason that "arcing" is so rare an occurrence in exhausting lamps by the recently introduced chemical process, which avoids the necessity of using mercury pumps.

THE ELECTRICAL INDUSTRY AT NEWCASTLE.

No. 2.

The manufacturers in the district of Newcastle are perhaps more alive to the value of the electric motor than those of most other districts. This arises no doubt from the persistence with which Newcastle engineers have advocated the use of the motors. In season and out of season (if such a state can apply to motor work) they have urged the necessity of electrical driving as a means of improving the economics of workshops, and their efforts have had such excellent results that the electric motor has become firmly established in ship building yards, in ironworks, and in the shops of many other trades in the neighbourhood.

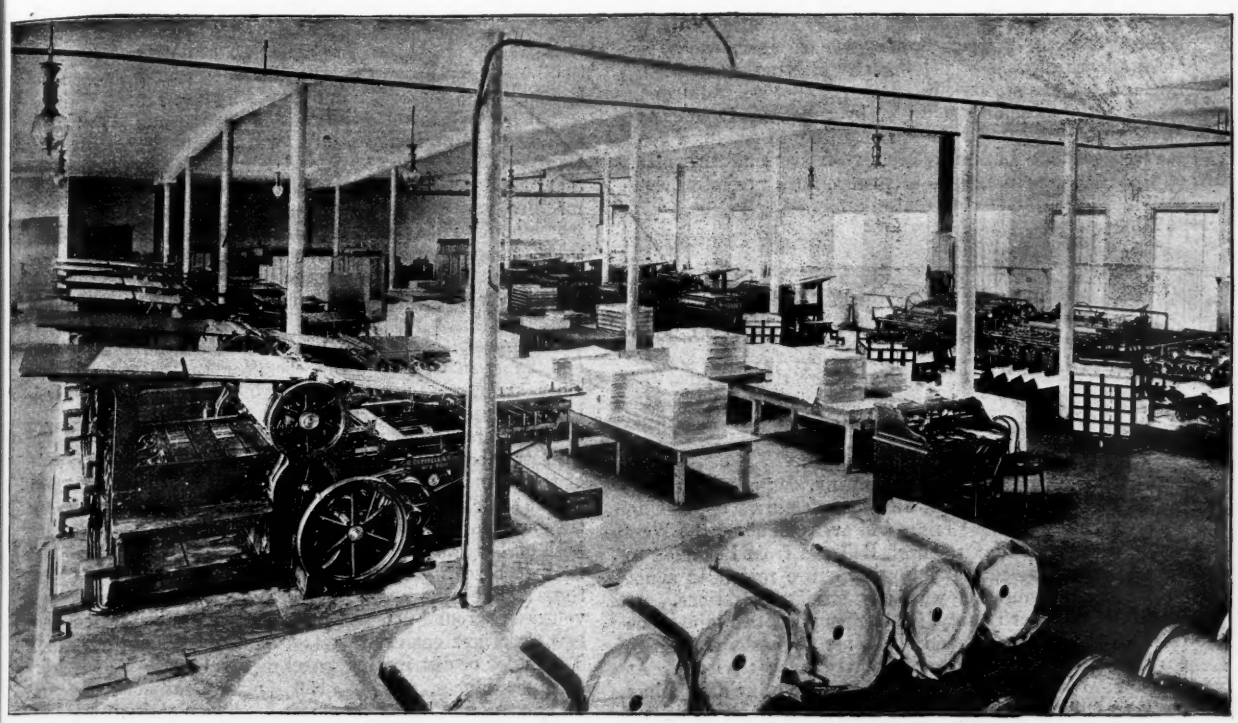


Printing Machine driven direct by a "Lundell" Six-Pole Slow Speed Motor.

Having regard to the leading position taken by Newcastle on this question, it would have been surprising if there had been no display of motor work at the Exhibition. One of the most interesting exhibits is that of the Lundell motor. It may be said to be ubiquitous, for not only is it showing the transmission of electrical energy in a most novel way, but it is in several instances demonstrating by actual driving the ease and economy of its working.

It is hardly necessary to say that Messrs. J. H. Holmes and Co. are the patentees and manufacturers of the Lundell motor for the United Kingdom, British colonies and dependencies, and on their stand at the Exhibition is shown the motor in various operations. The most interesting, and one which excites some amusing comments from the public, shows several stages of transmission. From a "Holmes-Willans" steam dynamo, power is conveyed to a 20 H.P. Lundell motor, which in its turn drives by belting a 15 H.P dynamo. This generates the current by which the second motor, a 10 H.P., is driven, which in its turn drives the second belt-driven dynamo. This method of transforming electrical energy into mechanical, and from mechanical again to electrical, is continued through a series down to a small dynamo of 1/12 H.P., which, however, is sufficiently large to supply current for the running of one 16-candle-power lamp. The special use that is being made of the Lundell motor is the driving of printing machines, a slow speed motor being coupled direct to a printing machine, and fitted with a special form of controller, which, in addition to starting and stopping the machine, will also give five variations of speed. A belt-driven printing machine is also shown.

The application of motors to printing machines is exceedingly interesting, and the illustrations which we give show two different machines to which electric motors have been attached. One shows a six-pole slow speed Lundell



View of Printing Works in which the Printing Machines are driven by Motors.

View of Printing Works in which the Printing Machines are driven by Shafting and Belting.

motor coupled direct to a printing machine, while the second shows a guillotine paper cutter driven direct by a Lundell two-pole moderate speed motor. There are also two interesting views in printing works, one of which shows the old-fashioned method of driving the printing machines by belting, and the second illustrates printing works in which each printing machine is driven by a motor. Comment is unnecessary. Messrs. Holmes, in addition to making a good showing with the Lundell motor, exhibit various other plant of their manufacture, such as pumps, fans, projectors, and ship lighting plant.

CENTRAL ELECTRIC STATION OF THE DAVIS COAL AND COKE COMPANY.*

By TIMOTHY W. SPRAGUE.

The Davis Coal and Coke Company, large miners and shippers of bituminous coal and manufacturers of coke in West Virginia, operating mines and ovens all along the West Virginia Central and Pittsburgh Railroad from Piedmont to Elkins, is the first company in that entire region to adopt electricity in connection with any mining operations. At Thomas, in Tucker County, the company has two mines, one operated as a drift mine and the other by a shaft, the two seams mined covering practically the same territory. At Coketon, about two miles distant, are two other drift mines and three banks of coke ovens, comprising in all about 500 ovens. There are a few ovens at Thomas also. The coal territory which is reached by the openings at Thomas and Coketon is of very large extent, and after a careful investigation it was decided best to locate the electric power station at Thomas, and make it a central distributing station for all these operations. This site was favourable also from the fact that a battery of boilers was already installed there for operating the shaft hoists and pumps, and a good water supply was available.

Accordingly the boiler capacity was doubled and a substantial power house built about 200 feet from the boiler-house. The power-house itself is of brick, laid on heavy stone foundations. It is 49 feet 2 inches × 52 feet 8 inches in extent, and the walls are 14 feet high. The walls are reinforced by 4 × 18-inch pilasters spaced 1 foot 5 inches apart, and large windows 4 feet × 7 feet 8 inches furnish good light. The roof is a steel truss structure, covered by 3-inch matched strips and a fireproof roofing material. The inside walls and roof are painted white, and with the coach black of the trusses present a very pleasing contrast, and at the same time make the interior very light. It is a fact, perhaps not generally recognised, that with a power-house interior attractive in appearance and well lighted, the incentive for the engineer to keep the apparatus correspondingly clean and bright is a strong one.

The flooring is 2-inch oak laid on joists 12 × 2 inch, which are in turn supported by heavy floor timbers. The foundations for engine and generator are of solid masonry extending some 8 feet through the soil to bed rock, and are entirely separate and distinct from the building and floor foundations. The building is designed to contain at least three units of power generation each of from 150 to 200 H.P. capacity. At present but one of these units is installed. It consists of a 15 × 21-inch simple engine made by the Atlas Engine Works, of Indianapolis, Ind., of a new type called the "Cycloidal." Its foundation is covered by a capstone of native sandstone with bevelled edge on which the iron base-frame fits. The engine itself is of massive construction, weighing complete a little over 16 tons. It is operated on an initial pressure of 80 lbs. per square inch, and runs at a speed of 200 revolutions per minute. The engine gets its name from the fact that the steam valves are operated for any port opening by the least motion of a simple cycloid. The exhaust valves are operated by a fixed eccentric.

The engine is belted to the generator by an endless double leather belt, 17 inches wide. The steam pipe leading to the power-house is designed to carry steam for the entire plant after additions are made. It is covered with an insulating material and leads into a separator immediately on entering the building. From the separator a smaller pipe leads to the engine, all piping having flanged fittings.

The generator, which runs at 900 revolutions per minute and is of 100 kw. capacity, was manufactured by the General Electric Company, and is wound for a potential of 500 volts three-phase alternating current. This type of machine was chosen on account of the long distances to which power will eventually be distributed, for which static transformers may later be required, and also because the three-phase motor offered some advantages in the work to which power was to be applied. From the generator the main leads and also the exciter and rheostat leads pass through the floor in heavy porcelain floor insulators and thence in conduits under the floor to the switchboard. They are carried on porcelain insulators, and are of best insulated cable, rubber covered and outside braided. The conduits are made perfectly tight, are painted with an insulating compound, and are accessible in all parts by means of trap doors in the flooring.

The switchboard consists at present of two panels, one for the generator and the other a distributing panel. They are both of blue Vermont marble, with all connections on the back of board. The generator panel carries a station transformer, lightning arresters, three main cut-outs, ammeter, voltmeter, ground detector, main switch, exciter switch, and two Carpenter enamel rheostats on the back of the board. The feeder or distributing panel carries 12 cut-outs and four circuit switches, two of 150 amperes capacity, one of 75 amperes and one of 30 amperes. The circuits from these switches are of heavy insulated cable for a distance sufficient to remove all possibility of short circuiting by contact, and thence are of bare wire. When the house was originally designed it was the intention to carry all the circuits out through the north wall, which is directly back of the switchboard, and a wire arch was placed therein. Afterward, when a change in the applications of power and location of circuits was made, more lines running south from the power-house were needed; hence the number of circuits which are carried through the house on the roof trusses, and pass out through porcelain tubes over the window.

The power is at present used in coal cutting and the operation of five elevators and conveyers. The coal-cutting circuits run distances of a little over half a mile in two directions in the drift mine, approximately north and south of the power-house. The north circuit passes in through the air course, and keeps in the air course all the way to the face except for a short distance where it is run along the main left haulway, partly along the roof and partly in a channel along the rib. Junction boxes are placed on the line near the face, from which connections are made to the machines through heavily insulated cables. These boxes are so located that two or more rooms can be reached from one box.

For the right or south side the current is carried overland for about half-a-mile, entering the mine through a newly opened manway. Thence it branches and covers a considerable territory along the main and cross entries. The junction boxes are installed here as on the north. The cutters are operated by three-phase induction motors. They are of the chain pattern, made to cut a kerf 39 inches wide and 5 inches high, to a depth of from 5½ to 6½ feet. Seven machines have been installed, four of the longer type and three of the shorter. They make a full undercut in from 3½ to 4 minutes in this coal and withdraw in 12 seconds.

The company has found it most advantageous to do the undercutting on a bench, about half way up the seam, which averages from 6 to 8 feet in thickness. The machine makes its first cuts in forming the bench, on an adjustable truck, and these trucks also take the machines readily off the bench for transportation to the next room. When cutting on the bench the upper part of the seam is shot down, and later the end of the bench is shot up. This plan has been proving very satisfactory during the time it has been in operation. The coal shoots more easily after the bench cutting than when the cutting was done on the floor, and more lump coal is obtained. It is estimated that the machine mining gives one-fifth more lump coal than pick mining.

* *Engineering and Mining Journal*, New York.

The shooting and loading of the machine mined coal is at present contracted on a basis of a little over 50 per cent. of the price paid for pick mining. The machines when operated to their capacity yield from 125 to 150 tons run-of-mine coal per machine per shift. Three machines are intended to be run on the right and three on the left, leaving one always in reserve. The company has adopted a rigid system of inspection, and the record of repairs of each machine is carefully kept. A repair shop, which is supplied with current has been fitted up near the bank mouth where the machines can be run in on their mine trucks; in it also is the carborundum grinding wheel on the armature shaft of a 1 H.P. induction motor, which is used for sharpening bits. The cutters themselves have already been illustrated in these columns. They are equipped with 10 H.P. induction motors, and their design places all gearing under the motor, where the gun-metal shield of the motor protects it thoroughly. The motors will develop 20 H.P. with safety, and the machine itself is mechanically well able to bear a greater strain. The first cutting done was in a "horse-back" bone formation, which is extremely hard and ground the bits in short order, but the motor and driving gear were equal to the strain. The bits on this machine are fitted into curving sockets, so that nearly all the stock in the bit can be utilised and the grinding and shaping is a very simple matter.

The old method of operating the elevators at Thomas was by means of a wire-rope transmission from a slide-valve steam engine. The rope led from the engine pulley to the first elevator tower, and, by means of a clutch, the rope leading to the second tower could be thrown in. The result was a great deal of vibration in the towers and great loss by friction and slip. As at present arranged, a 5 H.P. motor is geared with double speed reduction to the smaller elevator, having a duty of raising 400 tons slack per day of 10 hours, about 50 feet. A 10 H.P. motor for the shaft elevator has a proportionally heavier duty. The motors have been in constant use since first started, and have been responsible for no delays in this part of the plant. They are of the induction type, with no commutators or brushes, an important feature, as they are placed where it is necessarily exceedingly dusty. They require no attention beyond an occasional oiling and inspection, and are effecting a large saving over the former cost of operating these elevators. As no rheostats are required for starting these motors, the only apparatus used beside the motor is a three-pole switch and cut-out.

From the power-house a circuit is carried to Coketon, nearly two miles southwest. The poles for this circuit, also used by the right coal cutting circuit as far as the manway, are 30 feet 8 inch poles, firmly set 6 to 8 feet in the ground, placed at distances of about 125 feet apart, and carry two 4-pin cross-arms. The top of the pole also carries a pin, so that the two cross-arms and this pin provide for three circuits. These lines, and, in fact, all the outside lines and apparatus are thoroughly protected from damage by Wirt lightning arresters, of which 45 altogether are in use.

At Coketon, the company has a very extensive coke plant. Each of the bins has a capacity for holding about 800 tons of slack. The larries run under them and are charged from the charging doors, of which there are several for each bin. The bins are in size about 30 × 50 feet and 67½ feet high, with an inverted pyramid bottom. No. 3 bin takes slack from the tipple just below it, and No. 2 bin from the tipple on the extreme left. Connecting the two is a truss bridge, over which a conveyor runs. Both these elevators and the conveyor are operated by motors, all three being of 20 H.P. capacity each. The conveyors are of the oblong flight type, put in by Heyl and Patterson, of Pittsburg. The motor which runs the horizontal conveyor is in the middle bin, No. 2. It is controlled by a double-throw switch which is all that is necessary to obtain the reversal which is required in this conveyor. The heads and chutes are so arranged that either elevator can be made to feed into its bin or into the conveyor, the change requiring no delay, and as the conveyor can be reversed inside of a few seconds, the slack from either mine can be put in either bin at a moment's notice. This arrangement does away with the necessity for running both mines in order to get slack for both lines of ovens. One man looks after the motors and the manipulation of the chutes, &c. The saving effected by means of this method of operating cannot be estimated, as the bins are both new and their elevators were never operated by any other means, but it can readily be seen that it is considerable, aside from the convenience and the freedom from risk of frequent shut-downs. The elevators are not necessarily in constant operation, and if worked by steam several hours' notice would be required before starting, or else steam would have to be kept up at all times. Now, all that is necessary to start any or all the apparatus is the throwing in of one or more switches. During the trial of one of these elevators, when everything was rough and friction very great, a test was made as to what load the motor would carry, and it was found to stand a load of about 100 per cent. more than its rating.

It is probable that the use of electric power will be further extended this spring and utilised for haulage, pumping, ventilating, and other purposes.

The writer is indebted to Mr. F. S. Landstreet, general manager of the company, and Mr. W. R. Davis, assistant manager, for information kindly furnished regarding the operation of the plant.

AN AMERICAN VIEW OF THE METRIC SYSTEM.

Not merely here, but also in America, the cries of the metrical men are rousing opposition. Mr. Webber, a well-known American engineer, writes in *Cassier's Magazine* to point out, what we have often pointed out, that the metre and the millimetre are too large and too small for mechanical work. The millimetre has no basis of convenience, but we are asked to abandon our convenient linear measures in order to take up a system evolved by revolutionaries of France and crammed down the throat of the nations of Europe by the man who conquered all of them except only England and Russia. The metre represents, in fact, the sceptre of the conqueror, and two great nations alone stand clear of the brand. Now, England and Russia represent between them full 20,000,000 square miles of territory, and 455,000,000 inhabitants. Throw in the United States and the area is 24,000,000 and the population over 520,000,000. These figures of non-adherents to the metrical system have no weight with its advocates who look upon our aloofness as a crime, and argue that even Turkey has the metrical system. Bravo Turkey!

Now the inch is not too small for very considerable mechanical dimensions, as for a large 72 inches by 72 inches planer, or a 120-inch steam cylinder, and both the inch and the foot are capable of very convenient subdivisions. Three-fourths of the commerce and traffic of the world is carried on by some appliance built to English measures by English speaking people, and Mr. Webber asks why adopt another and more inconvenient system when we already have a system so convenient for both decimal and binary subdivision. To change our system destroys, says Mr. Webber, the value of all systems of screw threads, gears, patterns, and drawings, and reduces to waste paper the most valuable mechanical literature in the world. As a rule, it is majorities which prevail in this world. The adoption of the metrical system will be the prevalence of a minority, and this minority chiefly composed of Germans and others who have bowed their necks to the yoke of a foreign conqueror. The French savants who established the metre were good astronomers and mathematicians, but it is doubtful, says our author, if they were mechanics. Clever as were these men, they blundered even in fixing the length of the metre.

Had they been mechanics, we fancy they would have adopted as unit some measure of 100 inches, if they must have been decimalists. Grant that they had a correct idea as to system, all their ideas are negatived by the impractical length of their unit. Even the co-relation of measure and weight in the litre or cubic decimeter of water is of little general value. The four cubic inches of cast-iron to the pound is fortuitous truly, but equally valuable to the engineer who thinks in that unit for his castings, and for boilers he has an equally good unit in his 20 lbs. per square foot of ½-inch

boiler plate, or his 10 lbs. per yard of 1-inch square bar, or his rule for water pressure as d^2 pounds per yard. Many of the facilities of the English system derive their value from their connection with circular measure. Engineers are so largely concerned with circles that a system of measures, no matter how based, cannot be fixed to suit both d^2 and $d^2\pi$.

CORRESPONDENCE.

The Function of the Element in Cable Speeds.

Lightning describes as "a terrible instance of much ado about nothing" the article entitled "The Function of the Element in Cable Speeds," published in the ELECTRICAL REVIEW of April 16th. Thus, Sir, you are by implication charged with having provided your readers with five columns of illustrated matter—value *nil*.

The accuracy of my little investigation has been so amply corroborated in the columns of your esteemed contemporary, the *Electrician*, that it is only regard for you who accepted my work that draws from me this word of protest against *Lightning's* inaccurate dogmatism.

This contemporary has quite given itself away in the words "as though any message consisted of words of uniform length," which sufficiently gauge its knowledge of cable matters.

The information given by this week's *Electrician* is most satisfactory and welcome. It details the latest practice adopted by the most extensive cable administration in the world, and it shows that the data upon which this practice is based, and which have been arrived at "by a careful examination of the traffic carried by the Eastern and other systems," is in absolute agreement with the ELECTRICAL REVIEW article.

"The Function of the Element in Cable Speeds" is a small matter compared with the investigation carried out by the Eastern Company's technical experts—the last people in the world to undertake anything akin to "a terrible instance of much ado about nothing."

The Eastern Company's "constant" (3·7) is easily extracted from my own data as given on page 517 of the April 16th issue of the ELECTRICAL REVIEW:—

Number of contact elements contained in 4,844 letters constituting 1,000 words of ordinary language	= 12,493
Add a contact element for every space between letters	= 4,843
Total contact elements	= 17,336

$$17{,}336 \div 4{,}844 = 3\,6.$$

To this—as the *Electrician* points out—add 0·1 for the proportion to be added to each letter on account of the extra space allowed between words, a word for this purpose being taken as 10 letters:—

$$3{\cdot}6 + 0{\cdot}1 = 3{\cdot}7.$$

That is to say, "speed constant" in terms of contacts per siphon recorder letter = 3·7.

I cannot see that the method of taking a word as 10 letters for the above correction is quite exact for all cases, whereas my formula, whether modified for *contact* elements only, or applied to *contact* + *space* elements, is absolutely correct for results expressed in words of any (N) number of letters. Also it appears to me that a *word* as opposed to a *letter* speed-rate, once it is shown to be theoretically accurate would be universally acceptable.

The speed-rate in (say, 5-letter) words per minute can be multiplied into cable KRs when it is question of reporting on the working efficiency of cable circuits, for this is the object of the periodical reports of superintendents to headquarters.

This subject, moreover, is especially interesting to those members of the electrical profession whose work includes the drawing-up of core specifications for long submarine cables.

Finally, it is to be hoped that in future it will be possible for a student in cable problems to take up his pen without incurring a sweeping attack from a writer who has himself something to learn.

E. Raymond-Barker.

April 26th, 1897.

Submarine Cable Breaks and Repairs.

Your leader in the current issue has pointed out in a very timely and appropriate manner, that a thinly-attended meeting at Great George Street on the occasion of the reading or discussion of a submarine cable paper cannot be taken as an indication of any lack of interest on the part of those immediately concerned with this branch of the profession.

On these occasions the interested members who can attend and take part are almost limited to those engaged in the manufacturing companies, consulting engineers and electricians, and those technical representatives of the cable companies who happen to be home on furlough at the time; but the bulk of the members representing this branch are stationed abroad, and while at their far-off posts of duty look forward eagerly to the receipt of the Institution *Journal of Proceedings* to see if there is anything that will be of interest or assistance to them.

The value of the discussion would be greatly enhanced if it could be arranged to send proofs of a cable paper to leading members abroad in time to obtain their views about simultaneously with the discussion, so that any striking evidence or opinion bearing on the subject could be read out at the time at the president's discretion. But in the interests of these members abroad whose guineas annually enrich the coffers of the Institution to a very large extent, and to whose professional enterprise the Institution largely owes its origin, I am gratified to find that you, Sir, have taken the occasion of a small attendance at the discussion on Mr. Benest's paper to point out that this in no way can be taken as indicative of any want of interest.

H. D. Wilkinson.

Wimbledon, *April 28th*.

ON THE DIELECTRIC CONSTANT OF LIQUID OXYGEN AND LIQUID AIR.*

By J. A. FLEMING, M.A., D.Sc., F.R.S., and JAMES DEWAR, M.A., LL.D., F.R.S.

THE exceedingly high insulating properties of liquid oxygen and liquid air indicate that these bodies are dielectrics, and possess a dielectric constant or specific inductive capacity which it is necessary to determine. We have, therefore, lately made some measurements which have enabled us to assign a number representing, in all probability, a close approximation to these constants.

The remarkable non-conducting quality of these liquid gases for electricity enabled us to employ a method which, generally speaking, is not applicable to liquids other than those of very high specific resistance, or insulating power.

The method used by us in these experiments consists in the employment of a small condenser composed of metal plates which can be plunged beneath the surface of the liquid gas, and the capacity of this condenser measured when the dielectric between the plates is first gaseous air at ordinary temperature and pressure, and is next replaced by the liquid oxygen or liquid air. In order to determine the capacity of this condenser, which is necessarily small and of the order of 0·001 microfarad, we adopted the well-known device of charging the small condenser with a high potential (100 volts) and then discharging it into a much larger, well insulated mica condenser, having a capacity of about 0·5 microfarad. This process was repeated 10 times, and the larger condenser was then discharged through a standardised ballistic galvanometer. A specially constructed and highly insulated key was employed to charge the small condenser by means of a battery of 50 small lithanode secondary cells; and then to discharge it into the larger condenser. The success of this method depends entirely on the absence of sensible leakage in the condensers, and it is essential to show that the small condenser loses no sensible portion of its charge by leakage or conduction during the interval which elapses between disconnecting it from the battery and connecting it to the larger condenser, which acts as a reservoir.

In these experiments the small condenser consisted of 17 plates of carefully flattened aluminium, about 1 mm. in thickness; each plate being 5 cm. wide by 15 cm. long. In order to separate the plates, small distance pieces of crown glass were employed, each fragment being about 3 mm. square and 1 mm. thick. Four of these fragments were affixed to each metal plate with a touch of shellac at the four corners and one fixed in the middle. The 17 plates were then piled one on the other, the glass fragments acting as separators, and the alternate plates were connected together by wires soldered to each series. A metal clamp kept all the plates in position. The condenser so formed consisted of 17 plates, eight being the positive, and nine the negative surfaces. The glass distance pieces had a total surface of very nearly 1 per cent. of the total opposed surface of the plates. The condenser so formed had a capacity of 0·001031 of a

* Royal Society. Received December 8th, 1896.

microfarad when gaseous air at 15° C. and normal pressure formed the dielectric.

If such a condenser having a capacity C′ is charged to a potential, V, and then discharged n times in succession into a larger reservoir condenser of capacity C, it is easy to show that at the end of the n successive charges the quantity, Q, contained in the large condenser is given by the series

$$Q = C' V (m + m^2 + m^3 \ldots . m^n),$$

where

$$m = \frac{C}{C + C'}.$$

Hence we have

$$Q = C' V \frac{m}{1 - m} (1 - m^n).$$

The capacity, C′, of the small aluminium condenser may be considered to be made up of two parts; a part which is changed when liquid oxygen is substituted for gaseous oxygen or air on immersing the condenser, and which thereby becomes increased. If K is the dielectric constant of liquid oxygen, referred to that of gaseous oxygen at − 182° C. as unity; and if c is the capacity of this variable part of the condenser when the dielectric is gaseous oxygen, then K c is its capacity when liquid oxygen is substituted for the gaseous oxygen at the same temperature.

In the next place there is a small part of the whole capacity due to the glass separators. These, as a whole, have a surface very nearly equal to 1 per cent. of the whole surface of the metal plates, and a dielectric constant, as shown below, when cooled to − 182° C., of 5·0. Hence it follows that that part of the whole capacity of the condenser which is due to the glass separators, may be represented very nearly by 5 c/100.

This part of the capacity remains practically constant whether the condenser is lifted out of the liquid oxygen into the cold gaseous oxygen lying above it, and which is at nearly the same temperature, or put into it, as long as the condenser is very nearly at the same temperature in the two conditions.

Hence, when the small condenser is under the surface of liquid oxygen its capacity, C′, as a whole, is

$$K c + 0{\cdot}05\, c,$$

and the whole quantity of electricity, Q, given up to the reservoir condenser after n charges of the small one, charged to potential, V, have been put into it, is

$$Q = V c (K + 0{\cdot}05) \frac{m}{1 - m} (1 - m^n)$$

$$= V c (K + 0{\cdot}05) M,$$

where $m = \frac{C}{C + (K + 0{\cdot}05) c}$ and $M = \frac{m}{1 - m} (1 - m^n)$.

Again, when the small condenser is lifted out of the liquid oxygen into the gaseous oxygen lying on the surface, its capacity becomes $c + 0{\cdot}05\, c = 1{\cdot}05\, c$, and the whole quantity, Q′, stored up in the reservoir condenser, after n charges at a potential, V, is

$$Q' = V c (1{\cdot}05) \frac{m'}{1 - m'} (1 - m'^n)$$

$$= V c (1{\cdot}05) M',$$

where $m' = \frac{C}{C + 1{\cdot}05\, c}$ and $M' = \frac{m'}{1 - m'} (1 - m'^n)$.

If in each case the reservoir condenser is discharged through a ballistic galvanometer, the "throw" or elongation of which is proportional to the quantity of electricity sent through it, and if θ and θ' are the throws produced by the quantities Q and Q′, we have

$$\frac{\theta}{\theta'} = \frac{Q}{Q'} = \frac{K + 0{\cdot}05\, M}{1{\cdot}05\, M'}.$$

The ratio θ/θ' is given from the observations.

To solve this equation completely and determine K would be difficult, since the quantity, M, is a somewhat complicated function of K.

We know, however, that the ratio of M/M′ cannot be very far from unity. A rough experiment had shown that K was a number in the neighbourhood of 1·5, and a calculation shows that when 10 discharges of the small condenser are made in each case into the large condenser, and if the large condenser has a capacity of 0·5 microfarad, and the small one a capacity of nearly 0·001 microfarad, that the ratio M/M′ = 1,030/1,019 nearly. Hence M/M′ comes in as a correcting factor of about 1 per cent. in value.

Before relying on the above method, it was necessary to prove that the loss of charge of the small condenser was negligible during the time elapsing between the end of the charge and the end of the discharge of the small condenser.

We found on trial that although the small condenser had a capacity of only 0·001031 microfarad, it held its charge when charged with 100 volts, and placed beneath the surface of liquid air in the most extraordinary way. The test for insulation was as follows:—

The small condenser was charged with 100 volts, and discharged through the galvanometer instantly. The galvanometer throw was 95 scale divisions.

The small condenser was then charged and allowed to stand 10 minutes insulated. It was then discharged through the galvanometer, and the throw was 90 scale divisions. In like manner it was charged and insulated for 47 minutes, and the throw was then 80 scale divisions.

The above figures show that the charge of the small insulated condenser decreased only by about 15 per cent. in three-quarters of an hour when placed beneath liquid air, and hence the loss of charge in one-tenth of a second was quite inappreciable.*

The same remarkable insulation is found when the small condenser is held in the cold gaseous oxygen lying above the liquid oxygen. The low temperature of − 182° C. prevents any sensible leakage across the glass distance pieces, and also increases the specific resistance of the glass itself.

As a further instance of the very high insulating power of liquid air, we may mention that we charged the small condenser when immersed in liquid air with a Wimshurst electrical machine, and after insulating the condenser and waiting a few moments, closed the terminals of the condenser by a wire. A small spark was seen at the contacts. We thus constructed a little Leyden jar, the dielectric of which was liquid air, and the coatings the aluminium plates. This liquid Leyden jar held its charge perfectly.

Having satisfied ourselves in this manner that the condenser when immersed in liquid air would lose no sensible portion of its charge during the fraction (about one-tenth) of a second in which the charge and discharge key was moving between its contacts, we proceeded to experiment in the following manner. The condenser was placed in a very large vacuum vessel, holding about two litres of liquid oxygen, and it was charged as described, and discharged into a very good mica condenser, made by Dr. Muirhead, which had an exceedingly high insulation. The process of charging and discharging 10 times occupied, perhaps, two seconds.

The resultant charge having been measured on the ballistic galvanometer, the condenser was lifted out into the cold gaseous oxygen lying on the surface of the liquid oxygen, and before the condenser had time to alter its form by rising in temperature, the same process was repeated with the dielectric changed to gaseous oxygen at − 182° C.

The following Table I. shows the observed ballistic throws, all reduced to their equivalents at one common charging pressure of 100 volts:—

Table I.—Observations to Determine the Dielectric Constant of Liquid Oxygen.

	Potential to which the condenser was charged in volts.	Ballistic throw in cm., corresponding to 10 charges of the small condenser.	Ballistic throw, reduced to correspond to 10 charges of the small condenser at 100 volts.
Exp. I.—Condenser at ordinary temperature, 15° C.	103·3 103·2 103·2	7·7 7·75 7·75	7·45 7·51 7·51
Exp. II.—Condenser in liquid oxygen at − 182° C.	103·15 103·1 103·1 103·0	11·3 11·25 11·27 11·27	10·96 10·91 10·93 10·94
Exp. III.—Condenser in cold oxygen gas above the liquid oxygen at − 182° C.	101·3 101·2 101·2 101·2 101·2	7·65 7·6 7·6 7·58 7·56	7·55 7·51 7·51 7·49 7·51
Exp. IV.—Condenser in liquid oxygen.	101·3 101·2	10·9 10·85	10·77 10·72 } bad.
Exp. V.—Condenser in cold oxygen gas above the liquid oxygen.	101·3 101·3 101·3 101·3	7·60 7·60 7·58 7·57	7·50 7·50 7·48 7·47
Exp. VI.—Condenser in liquid oxygen.	101·4 101·3 101·3 101·3	11·1 11·0 10·95 11·0	10·95 10·86 10·81 10·86

Mean ballistic throw in gaseous oxygen = 7·502 = θ' Mean ballistic throw in liquid oxygen = 10·903 = θ.

It will be seen that the mean galvanometer throw, when the condenser was immersed in liquid oxygen, was 10·903 centims, and the mean throw, when raised into the gaseous oxygen, was 7·146 centims.

One matter which we felt it important to examine, was whether there was any correction needed for the change in the dielectric constant of the glass separators with temperature.

Since these glass separators had a total surface of nearly 1 per cent. of the area of the metal plates, the condenser may be regarded as consisting of two condensers joined in parallel, one consisting of a glass dielectric condenser having an effective surface of 1, and the other a condenser having a liquid or gaseous oxygen dielectric

* These figures do not of course measure the electrical resistance of the liquid oxygen alone. They show, however, that the immersion of the condenser in liquid oxygen enormously decreased or entirely destroyed any surface leakage over the small glass separators, and, as we have found by an independent examination, increased the resistivity of the glass itself. The specific resistance of liquid oxygen itself is exceedingly high.

having an effective area of 99. In the course of these experiments we have therefore examined the effect of low temperature upon the dielectric constants of glass, paraffined paper, and mica. We find that on cooling these bodies to − 182° C. they experience a marked reduction in dielectric constant. The dielectric constant of a certain specimen of crown glass was reduced by 21·4 per cent. by cooling to the temperature of liquid air or to − 185° C. The dielectric constant of paraffined paper was reduced by 28·4 per cent. under the same circumstances.* We are engaged in a systematic examination of the influence of very low temperatures on the dielectric constants and specific resistances of the principal dielectric bodies. The crown glass used as separators in the construction of our small condenser had a specific inductive capacity of about 6·0 at ordinary temperature, and this at the low temperature would be reduced to nearly 5·0. Hence in estimating the capacity of the condenser, as constructed, there comes in as we have seen a correction from the presence of the glass. We selected glass in the first instance rather than ebonite or sulphur, as we thought it probable we should use the same condenser in determining other dielectric constants, and we wished to construct the separators of a material which was very rigid and not easily acted upon by oils or other liquids.

Taking the formula above given, we can deduce from the observed results the required constant, for, we have

$$\frac{\theta}{\theta'} = \frac{\text{K} + 0{\cdot}05}{1{\cdot}05} \frac{1{,}030}{1{,}019},$$

and hence substituting for $\frac{\theta}{\theta'}$ the observed ratio $\frac{10{\cdot}903}{7{\cdot}502}$, we find

$$\text{K} = 1{\cdot}491$$

as the dielectric constant of liquid oxygen referred to that of the overlying gaseous oxygen at − 182° C. as unity. Since the aluminium condenser is at the same temperature when the two measurements are made, no correction is necessary for any change of form of the condenser.

To determine the dielectric constant of liquid oxygen in terms of that of a vacuum taken as unity, we require to know the dielectric constant of the gaseous oxygen lying on the surface of the liquid oxygen referred to the same unit.

Boltzmann and Klemencic have both shown that the true dielectric constant of air at a temperature of 0° C. and 760 mm. is 1·00059. That of oxygen gas at the same temperature and pressure is not very different. If the value of K − 1 for gases varies directly as the pressure, and if temperature *per se* makes no difference, then the dielectric constant of the gaseous oxygen lying on the surface of the liquid oxygen, and which has a temperature of − 182° C. nearly, and a density about three times that of the gas at 15° C., is not far from 1·002. Hence the correcting factor to be applied to the above value of the dielectric constant of the liquid is at the most 1·002, and the true dielectric constant of liquid oxygen at − 182° C. and under a pressure of 760 mm. is not far from 1·493.

We intend to examine this correction more closely.

As a matter of fact, we were not able to detect any difference between the capacity of the small condenser when held in air at ordinary temperature (15° C.) and pressure, and in the cold gaseous oxygen at — 182° C. lying on the surface of the liquid oxygen.

Until we are able to make a better determination we may take the above number, 1·491, therefore, as representing in all probability a close approximation to the dielectric constant of liquid oxygen.

The interesting question then arises how far does liquid oxygen obey Maxwell's law, by which the product of the dielectric constant and the magnetic permeability should be equal to the square of the refractive index for waves of infinite wave-length? The materials are at hand for making this comparison, as we have ourselves just determined the magnetic permeability of liquid oxygen, and find it to be 1·00287,† and the refractive index of liquid oxygen has been determined by Profs. Liveing and Dewar for several different wave-lengths.‡

(To be continued.)

THE LIMITING VELOCITY OF BELT AND ROPE GEARING.

An article on the limit of velocity of belts and ropes by Mr. Geo. R. Bale, in the *Practical Engineer*, treats the question from the standpoint that the highest possible velocity is desirable, but that such velocity should not exceed the point where centrifugal stress increases faster than the additional power due to increase of speed. Thus there are three principal stresses in a rope—the tension which exists on the slack side, the working tension, and the tension due to centrifugal force. The total tension is the sum of these three, and it follows that for the maximum of work the slack side tension must be the smallest that will ensure a sufficient grip. It also follows that the velocity must be such that the product of the working tension by the velocity must be a maximum. From this we may deduce that the best belts are those whose tensile strength has the highest ratio to the unit weight, for then the stress due to the centrifugal action will be the least. It also follows that the higher we allow the total unit stress the greater will be the maximum allowable velocity.

If the working capacity and centrifugal stress for various speeds be calculated out, it will be observed that from 3,000 to 6,000 feet per minute no very marked difference of working capacity exists for the reason that the increase of capacity due to velocity is approximately balanced by the decrease caused by the absorption of strength by the centrifugal force. Further, at the lower limit of speed there is far less wear and tear due to bending and rubbing friction, and in many ways there are good reasons not to be sorry if a fairly moderate velocity can be secured. At the same time, with high speeds, there is a superior fly-wheel action, and hence high speeds have become common and the even turning efforts have been attributed to velocity itself rather than to simple fly-wheel action.

Where the weight per foot run of belt is $= w$ and v = velocity in feet per second, the centrifugal tension $= \frac{w\,v^2}{32}$ lb., 32 being gravity. When a band is at rest it has equal tension on both sides; when running, the tension on the driving side is increased by an amount F, and

$$\text{F} = \text{T}\left\{\frac{1}{1 - 2{\cdot}718^{\frac{m\,a}{\text{R}}}}\right\},$$

where T is the tension due to driving, m = coefficient of friction, a = the length of the arc embraced by the belt on the smaller pulley, and R = radius of smaller pulley. The fraction in the brackets is thus constant at all velocities, and may be called x.

Then $\text{T}\,x = \frac{\text{P}}{v}$ where P is the power to be transmitted and $\text{T} = \frac{\text{P}}{x\,v}$.

If the band have a working allowance of stress, $\text{W} = \text{T} + t$, then $\text{W} = \frac{\text{P}}{x\,v} + \frac{v^2\,w}{g}$.

To find when P is a maximum, we have $\text{P} = \text{W}\,x\,v - \frac{x\,v^3\,w}{g}$ or $v = \sqrt{10{\cdot}7\,\frac{\text{W}}{v}}$.

Thus, for an allowed stress of 320 lbs. per square inch and a weight of 0·43 lb. per foot run of square inch cross-sectional area, we have $\frac{\text{W}}{w} = 744$, and $v = \sqrt{10{\cdot}7 \times 744}$, or 89·2 feet per second.

Approximately, the velocity in feet per minute may thus be written $v = 200\,\sqrt{\frac{\text{W}}{w}}$.

According as W is altered in value, so will the maximum velocity be varied.

Designers may thus choose their velocities over a wide range with safety, and should not allow themselves to be crippled by a strict adherence to some preconceived idea as regards velocity. Where the bad practice of running the slack side of a rope or belt down hill is compelled, from force of circumstances, attention to securing moderate velocities should be given. Rather than run a rope in this manner, we would prefer to reverse our engine and make the top side of the rope drive, and let the bottom side sag, and reduce the arc of contact, and increase, if needful, the number of ropes. But we have seen few electrical rope drives that have been rightly installed, and in the wrongly designed cases the correct method would have been equally easy to carry out. The wrongful arrangements due to electrical engineers are adversely criticised by ropemakers, who say plainly that it is of little good attempting to touch electrical work unless electrical engineers will consent to put ropes upon as fair a footing in respect of design as they allow to direct driving.

BUSINESS NOTICES, &c.

Auction Sale.—Messrs. Wheatley Kirk, Price & Goulty will offer for sale, on May 27th, some electrical engineering works at Mill Street, Ancoats, Manchester; also steam engines, boilers, lathes, drilling machines, dynamos, &c., at the said works, which are occupied by the Electric Engineering Company. From our "Official Notices" further particulars can be obtained.

Change of Address.—Mr. Archibald Wright, electrical engineer, says that increase of business has necessitated his taking larger manufacturing and warehouse premises at 318, Upper Street, Islington, where all communications should be addressed.

Electrical Illumination.—We understand that special arrangements have been made for the display of electric light advertisements on the Great Wheel at Earl's Court during the forthcoming Victoria Exhibition.

* By another method we have found that for the glass of a glass test-tube the dielectric constant was decreased 22·2 per cent. by cooling to the temperature of liquid air. Under the same circumstances a certain specimen of mica decreased only 3·01 per cent. in dielectric constant.

† See Fleming and Dewar, *Roy. Soc. Proc.*, December, 1896, Vol. 60, p. 283, "On the Magnetic Permeability of Liquid Oxygen and Liquid Air."

‡ Liveing and Dewar, *Phil. Mag.*, Sept., 1895, p. 269, "On the Refraction and Dispersion of Liquid Oxygen and the Absorption Spectrum of Liquid Air." See also Liveing and Dewar "On the Refractive Index of Liquid Oxygen," *Phil. Mag.*, August, 1892, "On the Spectrum of Liquid Oxygen and on the Refractive Indices of Liquid Nitrous Oxide and Ethylene;" also Liveing and Dewar, *Phil. Mag.*, October, 1893, "On the Refractive Indices of Liquid Nitrogen and Air;" also Liveing and Dewar, *Phil. Mag.*, September, 1888, "On the Absorption Spectrum (luminous and ultra-violet) of . rge Masses of Oxygen."

Electrical Wares Exported.

Week Ending April 27th, 1896	£ s.	Week Ending April 27th, 1897.	£ s.
Adelaide	3,222 0	Adelaide	21 0
Amsterdam	50 0	Alexandria	200 0
Beira	17 0	„ Telephones	64 0
Calcutta	33 0	Amsterdam	332 0
Cape Town	318 0	Antwerp	394 0
Delagoa Bay	100 0	Auckland	23 0
Demerara	78 0	Bombay	20 0
Durban	42 0	Buenos Ayres	413 0
Melbourne	50 0	„ „ Teleg. mat.	110 0
Port Elizabeth	28 0	„ „ „ wire	338 0
Piræus	25 0	Calcutta	273 0
Shanghai	110 0	Cape Town	311 0
Singapore	40 0	Christiana. Teleg. mat.	73 0
Stockholm	371 0	Colombo	53 0
Sydney	387 0	Copenhagen	75 0
Wellington	296 0	Durban	1,138 0
		„ Teleg. mat. ...	2,979 0
		East London	352 0
		Flushing	213 0
		Ghent	14 0
		Gibraltar	18 0
		Grenada. Teleg. mat.	15 0
		Hamburg. Teleg. mat.	610 0
		Kurrachee	166 0
		Madeira	882 0
		Melbourne. Teleg. mat.	280 0
		Port Elizabeth	1,205 0
		Port Nolloth	14 0
		Rangoon. Teleph. mat.	75 0
		Reval. Teleg. mat. ...	15 0
		Rio Janeiro. Teleg. mat.	510 0
		Rockhampton	17 0
		Rotterdam	250 0
		St. Petersburg	1,040 0
		Shanghai. Teleph. mat.	24 0
		Singapore	110 0
		Stockholm	156 0
		„ Teleg. mat.	214 0
		Sydney	1,132 0
		Wellington	351 0
		„ Teleg. mat.	66 0
		Yokohama	240 0
Total	£5,167 0	Total	£14,791 0

Foreign Goods Transhipped.

	£ s.		£ s.
Brisbane	288 0	Calcutta	55 0
Total	£288 0	Total	£55 0

Bankruptcy Proceedings.—The Official Receiver reports to the creditors in the bankruptcy of Reginald Ridings, electrical engineer, of Albert Street, Birmingham, that legal proceedings are being taken, with his approval, against Mr. Crawford, of London, a financier, to enforce an agreement which he entered into. The debtor, who owes £400 against assets of £120, states that in August, 1895, he entered into partnership with Mr. L. V. Codd, and they began business as electrical engineers. The debtor had £50, but Mr. Codd had no capital. In the following year Mr. Thomas Evans and Mr. George Bull were taken into partnership, the former bringing in a capital of £1,500. In July, 1896, they arranged to sell the concern to Mr. Frank Herbert Hodges, and a deposit of £50 was paid by Mr. Crawford. Subsequently Mr. Hodges transferred his interest to Mr. George William Richardson, who was to form a company after buying the business. The capital was to be £60,000, but the company had not yet been floated. The subscribers of the capital were to get in return various patents, including one of an arc lamp, about £1,200 worth of stock, and the goodwill of the business. The debtor is interested in the company project to the extent of being recouped in his share of the amount for which the business was sold, and he values the patents at being worth £10,000. The vendors were to have had £3,000 in cash from Mr. Crawford, as Mr. Richardson was merely a nominee so far as the transactions with the vendors were concerned. The proceedings against Mr. Crawford, as referred to above, are being taken by Mr. Evans.

The public examination of Messrs. Watson & Clark, manufacturers of electrical fittings and art metal workers, carrying on business at 23, Brook Street, Holborn, as J. W. Watson, Clark & Co., was held last Tuesday at the London Bankruptcy Court. The debtor Watson said he started the business in June, 1889, at Hatton Yard, E.C., removing shortly afterwards to Brook Street, and carried it on until he was sold up in January last by the landlord. To loss by such forced sale, combined with law costs and competition, he attributed the failure. The joint accounts showed total liabilities £5,307 of which £1,209 were unsecured and assets £129. The debtor Clark was also questioned and eventually the examination was ordered to be concluded.

Catalogues and Lists.—A new catalogue, dated May, 1897, is being issued by Messrs. J. P. Hall & Co., of Oldham. There are illustrations, descriptive details, and prices given of various types of dynamos, motors, and combined engines and dynamos, as manufactured by the firm at the Blackriding Iron Works.

The American Impulse Wheel Company, of 120 and 122, Liberty Street, New York, send us a copy of its 1897 publication, describing the various water and steam wheels turned out under the Cazin Impulse Wheel patents. The book before us is divided off into various chapters, with such headings as—"Modern Hydraulics," "The American Hurdy-gurdy and its Evolution to Perfection," "Authorities on Matters of Hydraulics," "The Cazin Wheel in its Standard Form," "Equations of the Foot-pound and the Metric Systems," list of standard water-wheels, table of pressure equivalents, horse-power, quantity of water and number of working revolutions, under heads of from 9 to 200 feet; the division of force jets, and various reprinted and other articles on matters of interest connected with water power and its utilisation. The *Western Electrician*, in a recent article describing the Cazin system, which is the invention of Mr. F. M. F. Cazin, says it is a wheel of the free jet or percussion type (operated by either steam or water), which appears to go beyond anything of the sort hitherto known to the mechanical world in developing maximum efficiency of the motive power.

Messrs. Bryan, Donkin & Co., Limited, of Bermondsey, send us a list of their exhaust steam valves, which are specially constructed for exhaust steam from engines, but are equally suitable for low pressures of steam, water, &c. Prices and particulars of the valves are given.

A number of lists have been issued by Le Carbone, of Carteret Street, Westminster, and Levallois-Perret, near Paris, describing the "Lacombe" central zinc cell, *Sans Pareil* dry batteries, "Central carbon" battery, carbon-headed plates for Leclanché and other batteries, carbon brushes, &c.

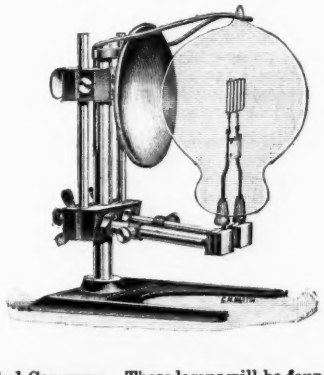
The International Electric Co., of Redcross Street, have issued a price list of their "Sirius" incandescent lamps.

Electricity in Madeira.—Acting Consul Bell, in a report to the Foreign Office on the trade of Madeira for 1896, says:—"During the past year, with the exception of a short narrow gauge tramway joining the pier with the Riggenbach Railway to the Mount Church, and the scheme to illuminate the city by electricity, no public works of any importance have been inaugurated in Madeira. The Madeira Electric Lighting Company, Limited, is an English-formed company, having a share capital of £35,000, of which £15,000 is debenture stock, bearing an interest of 5½ per cent. This company obtained a concession for 40 years from the Municipality, and are fast pushing forward the works towards completion. The necessary plant for the installation is of English manufacture, and has been admitted under special arrangement, free of duty. The contractors also are English, and they hope to have the works completed early in the summer, when the present means of illumination, which is by petroleum lamps, will be superseded by one which will be more in keeping with modern requirements."

Ediswan Fire Brigade.—We learn that the Edison-Swan Company's fire brigade at Ponder's End rendered excellent service at an extensive fire which occurred at the Corticine Company's factory on Good Friday evening. The Ediswan brigade, which was at work until noon on Saturday, have been much praised for the good work they accomplished.

Fire.—There was a small fire on Tuesday in the machine room of the premises occupied by Messrs. Allen & Adamson, electrical engineers, 88 and 90, Tabernacle Street, E.C.

Focussing Lamps.—We illustrate a focussing lamp which is being supplied, with stand and everything complete, by the Edison



and Swan United Company. These lamps will be found of service by photographers, electro-medical men, and others.

Gas.—Last Saturday a gas explosion occurred in the refreshment department of the Great Western Railway, Millbay.

On Sunday night a gas explosion occurred at Francis Street West, Hull. A great deal of damage was done to the house and contents.

Heathman's Ladders.—We understand that Mr. J. H. Heathman has made arrangements for keeping a stock of his patent telescopic tower ladders for lending out on hire.

Hint to Mining Machinery Manufacturers.—Mr. Chamberlain writes to the Glasgow Chamber of Commerce stating that he has received a communication from British Columbia calling attention to the rapid development of the mining industry in that country, and to the fact that the mining machinery supplied is practically confined to one Canadian firm and one American firm, no British houses being represented. Mr. Chamberlain thinks the Glasgow Chamber of Commerce should be made aware of the apparent neglect of a favourable opportunity.

Insulators.—The demand for manufactured slate and marble for electrical insulating purposes has led Messrs. E. & C. Braby, of Bangor Wharf, Belvedere Road, Lambeth, to study this branch, particularly in regard to the essential importance of carefully selected slate or marble, and the necessity for mathematical precision in the working of same. They are prepared to quote prices in plain or enamelled slate, or polished marble. A list of electrical engineering accessories of this description has been issued.

Liquidation Notice.—At meetings of the High Wycombe Electricity Supply Company, held at 31, Soho Square, on March 22nd and April 12th, resolutions were passed winding up the company voluntarily as the objects for which it was formed no longer exist. Mr. A. B. Bryden, of 43 and 44, Lombard Street, London, E.C., was appointed liquidator.

Meldrum's Calculator.—A novel and useful pocket calculator, designed by Mr. C. N. Pickworth, has just been issued by Messrs. Meldrum Bros., of Manchester, for the purpose of enabling users of steam power to easily ascertain the price they are paying for such power, and hence to compare the relative values of different fuels and the methods of burning them. The calculator takes the form of a neatly-made cardboard slide rule, upon which scales are arranged. By setting the I.H.P. to the number of tons of fuel burned per week, the fuel cost can at once be read off over the price paid per ton. Further, the calculator is so arranged as to enable the weight of fuel per I.H.P. per hour to be instantly ascertained, this result being also obtained by a single movement of the slide and without any calculation by the operator. Such a calculator enables the power user to keep his coal bill well under control.

Mix & Genest.—The annual meeting of shareholders of Mix & Genest, Limited, of Berlin, was held on Wednesday last week, when a most satisfactory report as to the last year's trading was submitted. The gross profit amounted to £24,310, which, after paying all expenses and writing off £3,530 on plant and tool account, leaves an available net profit of £10,440. This latter sum has been apportioned as follows:—£7,500 10 per cent. dividend, £2,300 directors' fees and gratification to the staff; £550 workmen's sick funds, and £90 carried forward to the new account. The report states that although the new and extended factory has only been in use for the last 18 months, the considerable increase of orders necessitated the erection of a temporary wing during last winter. The directors, therefore, propose to build on the still available site another factory of exactly the same dimensions as the one which was opened in '95, thus accommodating a further 1,000 hands. The company is increasing its capital by £30,000 debentures (the cost of the additional factory) and £15,000 of ordinary shares, which latter are offered to the old shareholders at a considerable premium. The prospects of the present year are stated to be the best, all departments being fully occupied for some time to come.

Revival of Business in America.—The electrical industry in the United States, though by no means in its infancy, has not yet passed the period of growth, for we understand that notwithstanding the many millions of dollars invested in electric light, power and traction undertakings, there is now on foot a revival in the electrical field, which is "assuming larger proportions, and experiencing a more healthy growth day by day," to quote an American exchange. It is believed that the American business crisis, particularly in electrical fields, is now past. Our contemporary says the crowded state of its news columns is a good barometer of the condition of business, there being so many occurrences to be recorded. We have ourselves found this to be the case for several years past. We on this side of the Atlantic, however, are not given to weekly boastings of the improved state of business; but we believe we are right in saying that all our leading electrical houses are crowded with orders, a condition which will last for a long time to come.

Sydney Exhibition.—On June 26th the Exhibition at Prince Alfred Park, Sydney, N.S.W., to which we have several times referred, opens and will remain open during July and August. Group 9 will be devoted to electrical machinery and apparatus, and other groups will be devoted to general engineering exhibits. In the electrical section will be included generators, conductors, testing and measuring apparatus, telegraph and telephone apparatus, electric lighting apparatus, electro-metallurgy and electro-chemistry, transmission, distribution and utilisation of power, lightning conductors, electro-thermic apparatus, and electro-medical apparatus. The Exhibition will be under the patronage of the Governor, Viscount Hampden. The executive committee appointed Mr. Edward Noyes, of Sydney, its representative in Europe and America. A New York electrical journal recently commended this opportunity of booming electrical apparatus in Australia to the attention of American firms. We also would commend the occasion to the British electrical manufacturer, and draw his attention to the fact that there are only two months before the Exhibition opens.

ELECTRIC LIGHTING NOTES.

Aberdare.—Llety Shenkin Colliery is now lighted with electricity. The work was carried out by Messrs. George Wilson and Sons, of Aberdare, who also lit the Abergorky Colliery some four years ago for the same owners.

Aberdeen.—The Corporation want a house wiring and mains inspector. See our "Official Notices."

Bath.—The Electric Lighting Committee has been going into the question of the extension of mains, and its recommendation to apply for a loan of £6,800 was adopted by the Council on 26th inst.

Bedford.—The Bedford Town Council propose to make an important extension in their electric lighting system, at a cost of about £20,000, of which sum £6,000 will be devoted to private lighting, £5,000 to public lighting, £300 for high tension mains and transformers at the sewage pumping station, £6,600 to machinery, £890 to buildings, £764 for the completion of the original electric lighting scheme, and the rest to contingencies. An application will be made to the Local Government Board for permission to borrow the money.

Belfast.—The Electric Light Committee reports that the accounts for the quarter ended March 31st show the gratifying increase of £208 1s. 3d. for current over the corresponding quarter of last year. The total output for the quarter was 53,743 units. Tenders for the engines required for the new station have been referred to the engineer to report upon.

Birmingham.—Following in the footsteps of Sheffield, we understand that the Town Council will shortly consider the advisability of buying up the Birmingham Electric Lighting Company's undertaking.

Bradford.—The Corporation want a switchboard attendant for low tension work. See our "Official Notices" for particulars.

Bulawayo.—The *Matabele Times* of March 20th stated that Mr. A. Lister has arrived in Bulawayo to take over the management of the electric light and water works as resident engineer.

Clerkenwell.—Dr. Evan Jones was successful at a meeting of the Vestry of Clerkenwell on the 22nd inst. in carrying his motion for the appointment of a committee to consider the advisability of the Vestry applying for an electric lighting provisional order. The motion had been on the agenda paper for no less than seven months.

Crieff.—Some years ago a proposal was set on foot to introduce electric light into Crieff. The scheme, however, fell through. During the past few days the proposal has been revived, and it is understood that a private company has been making overtures to the proprietor of Ochtertyre with regard to the water supply from the Barvick, and in the event of the Town Council not agreeing to enter into the project, it is not improbable that the right of utilising the waterfall may be conceded to the company. Sir Patrick Murray offers the use of the water and storage accommodation free to the town—his principal condition being that he shall obtain a supply of the light to Ochtertyre House.

Edinburgh.—Messrs. P. C. Middleton & Co. have secured the contract for the electric lighting of the Royal Hotel, Princes Street, Edinburgh, 1,100 lamps being required.

The Free High Church has just been fitted throughout for electric lighting.

Fulham.—The deputation appointed by the Electric Lighting and Dust Destructor Committee, to inspect refuse destructors, are to inspect the furnaces at Southampton.

Govan.—At the last meeting of the Combination Hospital Board, the proposed electric lighting scheme was again under consideration, and the report was allowed to lie over.

Hampstead.—The following figures were produced by the Finance Committee, as showing the increase of work in the Accounts Department, and an additional clerk is to be engaged:—

	Year ending Christmas, 1895.		Year ending Lady-Day, 1896.
Number of electric light consumers	246	...	550
Amount of consumers' accounts ...	£3,219	...	£10,860

It is understood that the widow of the man who lost his life in the sub-station recently, has instituted legal proceedings to decide whether the Vestry is liable for compensation under the circumstances of the case. The Vestry has been making her an allowance since the accident occurred, but has now suspended these payments, pending the result of the litigation.

The Electrical Engineer is to report to the Vestry on the question of lighting the Central Library by electricity.

Islington.—The report of the Electric Lighting Committee presented at a meeting held on the 23rd inst. stated that the Committee had considered the desirability of revising the present scale of charges for the supply of electricity to private consumers. The Committee had resolved to adopt the following scale on and after October 1st next:—For an average of one hour's consumption or under per day during the quarter, of the maximum number of lamps alight at any one time, 7d. per unit; an average of two hours per day, 7d. per unit for the first hour, and 6d. per unit for the second hour; and an average of three hours per day or more, 7d. per unit for the first hour, 6d. per unit for the second hour, and 4d. per unit for the remainder. The following notice of motion stands in the name of Mr. Littlewood:—That it be an instruction to the Electric Lighting Committee to consider and report to the Vestry:—1. As to the advisability and probable cost of lighting the following roads by electricity upon the completion of the work now in hand:—Hornsey Road and Rise, Tollington Park, Hanley Road, St. Paul's Road, Highbury Grove, Blackstock Road, Aberdeen Park, Highbury New Park, and Highbury Quadrant; and 2. As to the advisability of bringing the question of lighting Stroud Green Road before the Hornsey Urban District Council with a view of obtaining their co-operation.

Huddersfield.—The Council has increased the electrical engineer's (Mr. Mountain) salary from £250 to £350 per annum. It was stated at last week's meeting that the units registered, as compared with March last year, showed an increase of 36 per cent.; consumers had increased from March to April by 17; while 30,779 lamps were connected in March, the number in April was 31,902.

Johannesburg.—A correspondent wrote on the 1st inst.:—"At the meeting of the Sanitary Board yesterday afternoon, the report of the committee recommending the acceptance of Messrs. Davies's tender for the supply of upwards of £15,000 worth of electric plant for extension of lighting was confirmed. This is but a beginning. The entire work will cost a very large amount."

Nancy.—La Compagnie d'Electricite de Nancy, which supplies a very extended area with electric current for lighting and motive power purposes, is going in for further extensions. The company has placed an order with Messrs. Fabius Henrion, of Nancy, for the construction of two sets of continuous current plant, each set having a capacity of 400,000 watts.

Newcastle.—Those members of the Lighting Committee who can make it convenient are to go to Southport and Bolton for the purpose of examining the system of electric lighting in those towns on Wednesday, May 12th.

Newmarket.—The District Council had a proposal to abandon their application for an electric lighting order before them the other day, and it seems that the recommendation was adopted. An offer from the Edison & Swan United Company asking whether the Council would be prepared to dispose of the order was also before the meeting.

Newport.—At the St. Mark's Vestry, Newport, the question of lighting the church by means of electricity was discussed, and it was decided to leave the matter in the hands of the churchwardens.

South America.—A company has just been formed in Paris with a capital of £200,000, to be known as the Compagnie Générale d'Electricité de la Ville de Buenos Ayres.

Stafford.—The year's working of the electric light department shows a profit of £601, excluding the repayment of loan and the payment of interest. These latter payments required a sum of £902, so that there was only £301 to be met; and as last year a sum of £296 was carried forward, the department was just about able to pay its way.

St. Pancras.—At the Vestry meeting on Wednesday, the Electricity and Public Lighting Committee presented their accounts for the year ending December 31st last. These showed a revenue of £23,133 16s. 2d. from the Regent's Park station, and a net profit of £2,816 4s. 5d. To this was to be added £1,149 6s. 7d. brought forward from 1895. The entire profit derived from the working of this station was thus £3,965 11s. On the other hand, the King's Road station accounts, which from the beginning covered only a period of fifteen months, disclosed a loss of £4,766 3s. 7d. In explanation of this it was stated that up to the time when the station began to supply electric current, nearly £1,650 was spent in paying instalments and interest on loans and in meeting salaries, wages, and other working and standing charges. The demand upon the station was small when it commenced to supply, while the working expenses and standing charges were almost as high as when the station was delivering a large output. Of the £3,824 obtained from the sale of current, £1,670, or 43 per cent., was in respect of the last three months' working. The net result of the two stations' work was a loss of £807 12s. 7d. Exceptional charges, however, had to be met during the year for compensation and law charges in connection with explosions in the culverts which occurred in February, 1895; and the large expenditure involved for repairs to the arc-lighting mains owing to the breakdown of the public arc lighting in August, 1896. But for these accidents, and in spite of the loss in respect of the King's Road station, the year's working as a whole would have shown a profit instead of a loss. The accounts were adopted.

Whitechapel.—On the recommendation of the General Purposes Committee, who reported having considered the question of lighting the Workhouse and the Board of Guardian's Offices by electricity, it was decided to call in a competent electrical engineer to furnish the Board with a report upon the proposal.

ELECTRIC TRACTION AND MOTIVE POWER NOTES.

Bristol.—Taking advantage of the provisions of the Light Railways Act passed last year, the Bristol Tramways Company are applying to the Commissioners appointed under that measure for powers to carry a light railway electrically worked to Hanham, an extra municipal suburb of Bristol, on the eastern side of the city. Hanham occupies to-day much the same position that Kingswood did before the trolley system of electric cars came to its rescue.

Cork.—*Daily Tenders* says that the Corporation have refused an application made by the Cork Electric Tramways Company for permission to use a site in Eglington Street for the purpose of erecting a power station.

Dundee.—The question of electric tramways is just now occupying attention in Dundee. There is a proposal to extend the tramways from High Street to Hilltown and Strathmartine Road, and the Simplex electric system is receiving a good deal of attention from those interested in the scheme. The length of the line would only be a little over a mile, and the cost is roughly stated at about £8,000.

Germany.—The electric tramway, which has been constructed by the Allgemeine Electricitäts Gesellschaft, of Berlin, in the town of Bernburg, was put in operation on the 1st inst. The line is about 4 kilometres long.

Halifax.—The *Leeds Mercury* says that the Town Council has approved of the recommendation of a committee to adopt the overhead trolley system for Halifax, also that the Gas Works Committee provide the necessary generating plant, main feeders, cables, and meters. We believe, however, that the Tramways Committee is only this week making a tour of English towns for the purpose of inspecting electric tramways, and the Council would hardly be likely to decide the matter in its absence.

Liverpool.—A Wharncliffe meeting of the Liverpool United Tramways and Omnibus Company was held on Saturday last at Liverpool, Sir David Radcliffe presiding. The solicitor having explained the provisions of the Bill for transferring the undertaking of the company to the Corporation at a price equivalent to £12 15s. per share, the chairman, in a speech of considerable length, explained the negotiations that had taken place with the Corporation, and the reasons which had influenced the directors in coming to the arrangement embodied in the Bill. The Bill was unanimously approved by the shareholders. It was explained that the transfer would be completed on August 31st, and in the meantime the company would be entitled to pay its shareholders a dividend at the rate of 5 per cent. per annum, free of income-tax. Our readers will remember that the Corporation intend equipping the lines for electrical power.

Norwich.—The *London Gazette* for Tuesday last contains notice of application which is to made to Parliament in connection with the Norwich Electric Tramways Bill for certain additional provisions for additional tramways, street widening, &c.

On Thursday, last week, the Town Council held an adjourned special meeting to consider the electric tramway scheme. The discussion was very exhaustive, and ultimately the meeting was adjourned until the following morning.

Roumania.—The municipal authorities of Braila, Roumania, recently invited tenders for the concession for the construction and working, during a period of 35 years, of an electric tramway in the town. Tenders were received from four firms, Messrs. Schuckert & Co., of Nurembourg, Messrs. Felix Singer & Co., of Berlin, Messrs. Lindheim & Co., of Vienna, and the Helios Company, of Ehrenfeld, Cologne. The tenders are still under consideration.

St. Helens.—At the meeting of the Highway Committee last week, it was suggested that as it was possible the St. Helens tramways might be worked by electricity at some future time, it would be well for the members of that committee, who would have the care of the streets under the new conditions, to go over to Prescot to witness a demonstration of the "Simplex" system of electric traction that had been erected in connection with the British Insulated Wire Company's works. The Town Clerk said that matter had been placed in the hands of a sub-committee of the Parliamentary Committee, who would report to the Council, and the members would then have an opportunity of inspecting the system that was recommended.

TELEGRAPH AND TELEPHONE NOTES.

Telegraphic Interruptions and Repairs:—

Cables.	Down.	Repaired
Brest-St. Pierre (Anglo, 1869)	April 6th, 1895 ...	...
West Indies—		
Puerto Plata-Martinique	Dec. 19th, 1895 ...	...
St. Croix-Trinidad ...	Nov. 30th, 1896 ...	...
Jamaica-Colon	Feb. 6th, 1897 ...	...
Amazon Company's cable—		
Parintins-Itacatiara ...	May 5th, 1896 ...	...
Obidos-Parintins ...	Dec. 7th, 1896 ...	...
Benguela-Mossamedes ...	April 14th, 1897 ...	...
Hong Kong-Macao	April 20th, 1897 ...	April 23rd, 1897.
Assab-Massowah	April 25th, 1897 ...	...
Konakry-Sierra Leone ...	April 28th, 1897 ...	...
Landlines.		
Trans-Continental line beyond Masol	March 12th, 1896 ...	...
Carthagena - Barranquilla (Columbia)	July 4th, 1896 ...	...

April 7th, 1897.—Katarina-Larissa route impracticable.

April 9th, 1897.—Telegrams for Ecuador subject to censure at Guayaquil.

April 19th, 1897.—Chio-Syra route impracticable.

April 19th, 1897.—During war between Turkey and Greece, cable between Trieste and Corfu cannot be used for messages for Turkey; they must be sent *viâ* Bosnia, Montenegro and Servia.

The Ottoman Government announce that messages in secret language may not be sent to the Greek Minister and Consul in Turkey. They are to be in plain language.

April 21st, 1897.—Greek Administration prohibits secret language for private telegrams for Greece.

April 25th, 1897.—During the interruption of the Assab-Massowah cable, telegrams between these places are sent by boat.

April 29th, 1897.—Siberian lines interrupted between Stretenskaia and Djalinda.

New International Telegraph Lines.—It is stated that new telegraph lines are shortly to be erected between St. Petersburg and Berlin, and between St. Petersburg and Vienna.

Scottish Trunk Telephone Service.—The following letter has been received from the Postmaster-General by Mr. J. M'Killop, M.P. for Stirlingshire:—

"Sir,—With reference to previous correspondence, I am directed by the Postmaster-General to acquaint you that the special inquiries which his Grace has caused to be made with regard to the trunk telephone service in East Stirlingshire and the Airdrie district of Lanarkshire have now been completed. The officers of the Department who conducted the inquiry visited several of the principal subscribers to the Exchanges of the National Telephone Company at Airdrie, Coatbridge, Wishaw, Motherwell, and Hamilton, including Mr. Mitchell, of the Bank of Scotland, who wrote to you on the subject on the 11th ultimo. It was found that the complaints had reference generally to three points—viz.:—(1) The termination of the arrangement under which annual rentals were paid for the use of the trunk wires. (2) The strict enforcement by the Department of the three minutes' limit for trunk calls, and (3) Delay in securing communication with other places, including Glasgow. I am to explain that the plan of charging a separate fee for each trunk conversation is an essential development of the telephone system of the United Kingdom, which has been adopted by the Government as being the best adapted to meet the requirements of the public generally, and the Duke of Norfolk regrets that he is not in a position to adopt any system which would have the effect of creating a preferential charge in the interests of particular persons. The period of three minutes has been adopted uniformly throughout the United Kingdom as well as in international relations. Experience has proved that it is, generally speaking, ample, and the Postmaster-General is not in a position to allow a longer period to any person. Every care is, however, taken to ensure that persons using the trunk circuits shall receive the full benefits to which they are entitled; that they shall be duly warned when the period is about to expire; and that subscribers shall be given the option of taking a second period of three minutes on the expiry of the first. If particulars are given of any case in which these rules are not observed, the Duke of Norfolk will gladly cause special inquiry to be made in the matter. The inquiry has not shown that there is any general need for additional trunk facilities at the towns mentioned. So far as the Department is concerned, about 64 per cent. of the trunk traffic from those towns in Glasgow, and more than 93 per cent. of the traffic in the reverse direction, is conducted with less than three minutes' delay. The Post Office is bound, however, to deal with all calls in strict order of priority, and it is unable to accord preference to any one subscriber over any other subscriber, or member of the public, in this respect. The delay which sometimes arises in connection with calls to Glasgow is chiefly due to local causes at Glasgow, and this matter is receiving careful consideration not only from the Department, but also from the National Telephone Company. I am to add that the telephone service in the district in question will continue to receive the Duke of Norfolk's careful attention, and, if it be found that additional trunk facilities are required, his Grace will at once cause steps to be taken to provide them.—I have the honour to be, Sir, your obedient servant,

April 15th, 1897. J. C. Lamb.

Telegraph Posts in the Country.—Mr. Walter C. Renshaw, of Sandrocks, Haywards Heath, writes to the *Times*, calling attention to the methods of the Post Office in connection with the erection of telegraph or telephone lines. He says:—"Here in Mid-Sussex one of our main roads—namely, that leading from North Chapel *vid* Lindfield to Brighton—has lately been made avail of, not for any purposes relating to local service, but in order to facilitate direct telephonic communication between London and Brighton exclusively. This work is being executed on a large scale. The posts, some 30 feet high, are fully a foot in diameter, and are maintained in some cases by converging wooden props inserted in the ground about 2 feet or 3 feet from the main post, and in others by metal stays set at varying distances, but in either case making a sort of trap. The general results are a hideous disfigurement of a hitherto pretty country, and an addition of danger in case of a runaway horse, or a bicycle running down hill out of control, which, having regard to what I call the traps, makes one shudder to contemplate. The particular results are a great diminution in the frontage value of land, and permanent obstruction to the opening of new gateways or roadways into the high road, without any compensation to the person aggrieved. But all this when the road authorities, with more or less indifference, give their assent, appears to be legalised by the Telegraph Act, 1863, into which for 'company' must under the Act of 1868 be read 'Postmaster-General.' Now, what I complain of is that in carrying into execution the wide powers conferred upon the Postmaster-General by them and the other Acts, no regard is paid by his officials to the provisions contained in them for the protection of landowners and others. . . . . I wrote to the Secretary of the Post Office on January 31st complaining of trespasses, and on February 2nd received an acknowledgment stating that my letter should receive attention. It has received such prolonged attention that I have never had an answer yet. This very morning workmen were engaged digging a large hole in one of my hedge-banks, which the foreman frankly admitted was my property, but said he was under orders to do it."

Telegraphic Interruption.—Telegraphic communication between Jersey and England is stated to be seriously interrupted, and carried on by one wire only. The rupture is between Jersey and Guernsey.

Telegraphic Communication to Iona.—Telegraphic communication between Iona and the mainland was opened on Wednesday last week. The first message sent was to Her Majesty in the name of the inhabitants, congratulating her on her record reign.

Telegraphs in Time of War.—The Press Association's Glasgow Correspondent telegraphs that the Eastern Telegraph Cable Company announce that they are unable to accept cablegrams for Constantinople and Turkey generally. Upon inquiry at the company's offices in London it was ascertained that as the company's cables to Turkey pass through Greek territory, the authorities at Athens had forbidden the transmission of messages to towns in the Ottoman Empire. In view of the above, it is pleasant to learn that the Indo-European Telegraph Company's direct route to Turkey is entirely unaffected by the present condition of affairs in Eastern Europe, and telegrams are transmitted as heretofore. Messages should be marked "*Viâ* Indo."

"Mediæval dilatoriness" is the term applied by the *Cape Times* to the way in which British and Colonial statesmen treat the chaos to which our cable system would most certainly be reduced on the outbreak of that general European war which has seemed so near to us of late. It says:—"A message which can be printed without a moss-grown date on it, and the apologetic headline, 'Delayed in Transmission,' almost makes a sub-editor's eyes glisten with grateful tears as he puts on his hat and goes home pondering the march of science. Very few weeks pass without one or other of the two lines controlled by the Eastern Telegraph Company, on which South Africa depends, being broken down; and when one breaks down the other is regularly blocked. It will be long before England forgets the nine days' block which piled up suspense and bewilderment just at the critical point of the Jameson crisis." To the above we would add that as the Benquila to Mossamedes cable broke down on April 13th, and is still interrupted, telegrams cannot reach the Cape at present by the West Coast of Africa route.

CONTRACTS OPEN AND CLOSED.

OPEN.

Bath.—May 6th. The Corporation want tenders for the supply of two electroliers to be fixed in the Roman Promenade. See our "Official Notices" for further particulars.

Belfast.—May 6th. The Electric Committee want tenders for the supply and erection of boilers, batteries, overhead traveller, supply and laying of cables, conduits, junction boxes, and various plant, apparatus, and work in connection with the new electric lighting scheme. Electrical Engineer, Mr. V. A. H. McCowen, Central Station, Chapel Lane, Belfast. See our "Official Notices" for further details.

Blackburn.—May 8th. The Corporation invites tenders for the supply and erection of electric tramway equipment including two dynamos, switchboard, posts, and bracket arms, overhead line equipment, underground cables, &c., &c. Consulting engineer, Mr. E. M. Lacey, 10, Delahay Street, Westminster, S.W.

Dundee.—May 12th. The Gas Commissioners want tenders for arc lamps, pillars, Lancashire boiler, engine and dynamo, accumulators, switching gear, &c. City Electrical Engineer, Mr. W. H. Tittensor. See our "Official Notices."

London.—May 13th. The Great Eastern Railway invite tenders for the supply of stores and materials, including telegraph materials, india-rubber, bolts, screws and rivets, and various sundry supplies. Forms of tender from the Secretary, Mr. W. H. Peppercorne, Liverpool Street Terminus. See our "Official Notices" for further particulars.

Malta.—May 4th. The Receiver-General and Director of Contracts at Valetta invites tenders for a 200 kw. steam alternator, a steam engine to drive same (direct connected), also a water tube boiler. Particulars may be obtained upon application to the Superintendent of Public Works in Malta, or the Crown Agents for the Colonies, Downing Street, London.

Manchester.—May 12th. The Electricity Committee invites tenders for the purchase of six 100 I.H.P. Hornsby engines and six 60-unit Elwell-Parker dynamos. The plant, which is now at the electric light station in Dickinson Street, was put down in 1893, and is to be disposed of in consequence of the Committee having decided to put down larger plant. See our "Official Notices."

Roumania.—August 20th. Tenders are being invited by the General Direction of the Roumanian Posts and Telegraphs in Bucharest for the supply of 55,000 porcelain (double-bell) insulators. Tenders to be directed to the Direction Générale des Postes et des Telegraphes, Bucharest.

Spain.—June 8th. The Spanish Ministry of Public Works in Madrid is inviting tenders for the concession for a projected electric tramway between Barcelona and its suburbs. Tenders to the Direccion Generale des Obras Publicas, Madrid.

Sunderland.—May 26th. The Corporation is prepared to receive tenders for a high-speed three-crank steam dynamo. Particulars from Mr. J. F. C. Snell, the Borough Electrical Engineer. See our "Official Notices."

Wakefield.—June 2nd. The Wakefield Board of Guardians want tenders for the following work for the new infirmary:—1. Electric lighting plant, combined steam engine and dynamo, belt-driven dynamo, motor dynamo, motor, switchboards, storage cells, &c.; 2. Complete system of wiring for the electric light, also bells and telephones; 3. Vertical steam engine, feed water heater, tank, pumps and pipe work, &c. Particulars from Messrs. Shepherd & Watney, engineers, 71, Albion Street, Leeds.

West Ham.—May 11th. The Town Council want tenders for pipe works, feed pumps, and feed water tank, &c. Particulars from the Borough Electrical Engineer, Mr. J. J. Steinitz. See our "Official Notices."

CLOSED.

Hampstead.—The Vestry has accepted the tenders of Mr. W. Flower (£262) for preparing the foundations and engine beds for the new alternator and two arc lighting dynamos at the central station.

NOTES.

Some Chimney Figures.—The *Street Railway Review* gives some figures of chimney weights that may be useful. For a chimney of a height of 193 feet above foundation, the latter is made 37 feet square for a ground requiring a good distribution of load. First 18 inches of concrete is laid, next 10-inch steel beams, spaced at 9 inches C. to C., and weighing 25 lbs. per foot, are laid in three crossed layers, and completely bedded in concrete. These bring up the depth to 4 feet, and above this there are four circular beds of concrete, each 2 feet thick, and stepped in at a pitch of 60°, so that the upper one is little larger than the chimney base. This is 17 feet diameter and three bricks thick, and contains an inner firebrick shaft, 8 feet inside diameter, three rings thick. The chimney top is 7 feet inside diameter and one ring thick, the outer shaft having an outside diameter of 10 feet 6 inches under the cap. The thickness at this point is 1½ bricks. There are thus three "set offs" of half a brick in the outer shaft, and three thicknesses for inner flue. The chimney batters $\frac{22}{100}''$ of an inch per foot outside, and $\frac{3}{100}''$ inside the inner shaft. In the outer casing the reductions of thickness take place at 50′·6″ above base, and at further heights of 47′·6″ and 47′·6″. The inner flue is carried up at the batter named above, and reduced when it approaches the outer shaft, against which it is steadied by ribs projecting from the outer shell. The total weight is 1,588½ tons, of which 572 tons are in the foundation, and the load on the foundation is 2·9 tons, and on the ground beneath 0·86 tons per square foot. In the particular chimney described, the inside flue is not built in firebrick, for the intended temperature is only 500° to 600°. The whole is in cement mortar. The omission of at least one ring of firebrick is a mistake. A chimney of the above dimension requires 389,229½ bricks. The half brick is good. These bricks are of the American size, 8″ × 3⅝″ × 2¼″, which run 21½ to the cubic foot. A full sized English brick 9″ × 4½″ × 3″, when laid measures nearly twice the cube of an American brick; but the American brick, which seems to have been brought originally from Holland, as to its dimensions, has a better appearance when well laid. A steel chimney with a brick lining would not weigh more than 285 tons, or about a fourth that of the all brick chimney; but a chimney would have its steel shell $\frac{11}{16}$th thick at base, tapering off to ½ and ⅜-inch higher up. The requirements of stability insist on bolting down to a weighty foundation.

"Lightning" Speeds.—Some of our readers may be aware of the touch and go criticisms which every week appear in the pages of a contemporary, under the heading "Our Review of Reviews." The writer of them is peculiarly versatile; he can seem wise upon everything, from a "quasi-mathematical formula" to a misprint. He has a sort of sagacity in smelling out trifles; a kind of instinct which disposes him to dwell at disproportionate length upon the remoter issues of his brother journalists. His wisdom shines forth like a pearl—that ought to have matured a little longer in the oyster. For instance, in criticising an article by Mr. Raymond-Barker on cable speeds that appeared in our columns two weeks ago, he sums it up as "a terrible instance of much ado about nothing." He misses the whole point of the word-value of "spaces," and makes up for it with a supercilious protest: "As though any message consisted of words of uniform length!" As though it did, indeed! Nevertheless, we insist that Mr. Raymond-Barker's suggestion is a good one. *Apropos*, the alternative speeds referred to in the daily press, with regard to the various tenders for the Pacific cable, are given as 12, 15 and 18 five-letter words per minute, a statement which must now be considered ambiguous.

Testing Pictures by the Röntgen Rays.—A correspondent says: In the possession of Herr Friedrich Burger, of Munich, is a fine old painting of the Saviour crowned with thorns, which has been generally ascribed to Albrect Dürer, though some critics had expressed themselves as doubtful on this point. In 1893 the Grand Duke of Baden had discovered after a long and careful search the monogram of Dürer, and determined the date 1521. As this discovery did not satisfy all the sceptics, the owner of the painting conceived the novel plan of submitting the painting to the action of the Röntgen rays. After many unsuccessful attempts, success was at last attained. The magical picture produced by the Röntgen rays excited the greatest interest and astonishment. The picture of the thorn-crowned Christ was exactly reproduced with correct light and shade, also the cross nimbus surrounding the head and marked above with the initials A and D. Moreover a signature was discovered in late Gothic characters, and Dürer's monogram with the date 1521 as had already been made out by the Grand Duke of Baden. The picture was painted on silk stretched on an oaken board 2 cm. thick, covered with interlaced oak fibres, and these are all shown distinctly in the Röntgen image. This application of the Röntgen rays may prove of considerable value to picture dealers and others in detecting fraudulent imitations of valuable paintings.

Electric Hansom Cabs and Motor Cars.—It is of course understood that we do not take responsibility for remarks made by our correspondents. In our April 2nd issue a letter appeared on page 463 regarding the Providence motor-car race, and our correspondents asserted that in the *Scientific American's* report respecting the race it is made to appear that the Morris-Salom system was the winner. An American correspondent has drawn our attention to this statement, and in a copy of the same journal for September 26th before us, we find it clearly stated that the first prize was adjudged to the Riker Electric Motor Company. The "Electrobat" made 5 miles in 11 minutes and 27 seconds. Our correspondent also draws attention to a paragraph on the same page headed "Horseless Cabs in New York." The London daily press stated that horseless hansom cabs had been appointed regular stands, and were doing good business. We are told by our well informed correspondent at New York that there are only seven or eight horseless hansom cabs in New York City, and these are not located at cab stands, but are kept in a stable ready to be brought out when ordered. While it is true that the charges are the same as for the hansom cabs drawn by horses, it should be remembered that cab hire is so expensive in New York as to make horseless cabs remunerative at similar rates. The rate of cab hire is 50c. per mile. It is interesting to observe that although over six months have elapsed since the coming into force of the Horseless Carriage Act, motor cars are rare in the London streets, and when let loose are generally followed by a laughing and a gaping crowd. One hardly expects a revolution of this sort to do its work in six months, but those who believed the reports of some promoters and inventors circulated last November expected something more than is to be seen to-day.

Test of a Wave Motor.—A new wave motor has been publicly tested on the beach near Los Angeles, California, from the end of a 100 foot wharf, by the inventor, Parvin Wright. By means of the float, a hydraulic compressor was actuated, forcing the water into a pressure tank under a working pressure of 400 pounds to the square inch. The water pressure tank operates a Pelton wheel, which drives any kind of machinery. In the test an electric generator was used. Where the machinery was located 500 feet from the beach with a four-foot tide and 6-10 float, it is said five horse-power was easily generated. The machine is automatically regulated and is so arranged that during storm periods no more than a given amount of power or pressure can be accumulated. According to the *Western Electrician* the cost of steady power at the coast will not exceed $10 per horse-power per annum. Power can be delivered in Los Angeles for $25, about one-third the present cost.

The Cause of a Fatal Accident.—Two Philadelphia lads recently observed sparks coming from a street fire alarm box. A crowd gathered, and one of the lads was persuaded to turn an alarm. Immediately upon touching the handle he fell dead. It seems that the trouble was caused by two electric light wires coming in contact with a guy wire, which was fastened to the pole on which the fire-box was placed, and to another pole on the opposite side of the street. The insulation on the electric light wires was worn off, and the current was conducted to the guy wire, and through that reached the metal tubing in which the alarm box wires are encased. In this manner the box became charged. Several expert witnesses testified at the inquest, and the jury supported the view, that the only way in which electric wires could be placed to ensure safety is to have them placed underground.

Tropenas Steel for Dynamo Magnets.—The Tropenas pneumatic steel process is a modification of the Bessemer process. It consists, says the New York *Electrical Engineer*, in decarbonising pig iron, melted in the usual way, by means of air compressed under a light pressure. To accomplish this a special converter, different in many points from the Bessemer and other similar apparatus, is used. In brief, the Tropenas process differs from the other pneumatic processes in the following characteristics:—The compressed air does not penetrate into the metallic bath, but acts only on its surface. Contrarily to all other similar processes which have in view the agitation, more or less, of the metallic bath, all the arrangements of the Tropenas process tend to keep the bath as quiet as possible during the operation. By so doing, Tropenas avoids giving to the metallic bath any further agitation than the natural one caused by the chemical reaction going on in the bath. In the Bessemer operation, nearly all the carbon contained in the metal is transformed into carbonic oxide, the proportion in volume reaching from 20 to 30 per cent. of the total quantity of the escaping gases, while in the Tropenas process, the top row of tuyeres allows of the rational burning, above the surface of the metallic bath, of all the carbonic oxide arising from the metal, thus increasing considerably the temperature of the final steel. Tropenas steel has been found to be specially adapted for the magnets of dynamos. Tests made by Prof. J. A. Ewing on five samples, some cast at intervals of two years, show it to be of remarkable uniformity in its magnetic properties. According to Prof. Ewing, Tropenas steel may be relied on to take up, under the action of any assigned magnetising force exceeding 30 units, an amount of magnetism which is not only absolutely very high, but is capable of being stated beforehand within narrow limits of probable variation. Prof. Ewing considers this steel an exceptionally good material for dynamo magnets.

Institution of Electrical Engineers (Students).—The next visit of the Students of the above Institution will be to the Great Eastern Railway Electric Light Station on Saturday, May 8th. The party will meet on No. 9 platform, Liverpool Street Station, at 11 a.m. As the number will have to be limited, those desiring to take part in the visit must send in their names at once to the Students' hon. secretary (Mr. W. Bunn, 23, Oxford Road, Stroud Green, N.).

Damages.—While driving down Charing Cross Road last June, a cabman named Larpinière was killed by his cab being overturned, owing to alleged negligence on the part of Messrs. Mowlem & Co., who were putting down an electric light installation at the Garrick Theatre at the time of the accident. The widow claimed damages for the loss of her husband, and on Tuesday, when the case came before Mr. Justice Wright and a jury, she was awarded £250.

Obituary.—The death is announced of L. P. Casella, F.R.A.S., F.R.G.S., F.R.Met.Society, at the age of 86. The *Times* of Tuesday says, in an obituary notice of Casella:—"Of the many new devices for travellers and explorers, probably few were more important than the adaptation of the pressure gauge to the verification of thermometers for determining the temperature at great depths in the ocean where the pressure per square inch of surface can only be adequately expressed in tons." Casella's instruments have, as cable men are aware, done good service in the surveys made preliminary to the laying of submarine cables.

Institution of Civil Engineers.—At the annual general meeting of the Institution of Civil Engineers on Tuesday, Mr. J. Wolfe Barry, C.B., president, in the chair, the result of the ballot for the election of officers was declared as follows:—President, Mr. J. Wolfe Barry; vice-presidents, Mr. W. H. Preece, C.B., Sir Douglas Fox, Mr. James Mansergh, and Sir William Anderson; other members of council, Mr. Horace Bell, Mr. Alex. R. Binnie, Mr. T. Forster Brown (Cardiff), Mr. Henry Deane (Sydney), Mr. W. R. Galbraith, Mr. George Graham (Glasgow), Mr. J. C. Hawkshaw, Mr. Charles Hawksley, Mr. G. H. Hill (Manchester), Dr. John Hopkinson, F.R.S., Mr. J. C. Inglis, Dr. Kennedy, F.R.S., Mr. John Kennedy (Montreal), Mr. George Fosbery Lyster (Liverpool), Mr. William Matthews, Sir Guilford Molesworth, Sir Andrew Noble (Newcastle), Dr. B. B. Stoney, F.R.S. (Dublin), Mr. F. W. Webb (Crewe), Sir William White, and Sir E. Leader Williams (Manchester).

With a view to promote the interests of many of the country members who are unable to attend the weekly meetings, arrangements have been made to hold a general conference of the Institution in London on May 25th, 26th, and 27th. Since the last annual general meeting, Mr. James Forrest had retired from the post of secretary, which he had held for 40 years, and had been appointed honorary secretary. An appreciation of Mr. Forrest's services, extracted from the President's Inaugural Address, was inserted in the report. Mr. Forrest had been succeeded in the secretaryship by Dr. J. H. T. Tudsbery, who had for several years acted as his principal assistant. During the past year, two honorary members, 37 members, 279 associate members, and 14 associates have been elected into the Institution, being a total of 332; while by death, resignation, and erasure, 158 names had disappeared from the register. The roll now numbered 6,204, as against 6,030 at the corresponding date last year. There were also 886 students attached to the Institution, so that the total number borne on the books on March 31st, 1897, was 7,090. The preliminary report of the committee appointed last year to consider and report upon the definition of a standard or standards of thermal efficiency for steam engines has been adopted by the Council. The gist of the conclusions they have come to is as follows:—

1. That the statement of the economy of a steam engine in terms of pounds of feed-water per I.H.P. per hour is undesirable.
2. That for all purposes except those of a scientific nature it is desirable to state the economy of a steam engine in terms of the thermal units required per I.H.P. per hour (or per minute), and that if possible the thermal units required per brake H.P. should also be given.
3. That for scientific purposes the thermal units that would be required by a perfect steam engine working under the same conditions as the actual engine, should also be stated.

The proposed method of statement is applicable to engines using superheated steam as well as to those using saturared steam, and the objection to the use of pounds of feed-water, which contain more or less thermal units according to conditions, is obviated, while there is no more practical difficulty in obtaining the thermal units per I.H.P. per hour than there is in arriving at the pounds of feed-water.

For scientific purposes, the difference in the thermal units per I.H.P. required by the perfect steam engine and by the actual engine shows the loss due to imperfections in the actual engine.

A further great advantage of the proposal is that the ambiguous term "efficiency" is not required.

The committee will submit their complete report at an early date.

Trade with Canada.—The preferential trade which Canada intends introducing should benefit most classes of machinery manufacturers in this country. We understand that under the new tariff arrangements the restrictions on the importation of mining machinery are abolished, and it enters free of duty, and the tariff on iron and iron manufactures is appreciably lowered. The *Daily Telegraph* states that in electric light apparatus, brass and copper, and iron and steel manufactures, the United States has so far had the advantage over us; but in these directions we may hope, under the altered conditions, to do a good deal more than formerly.

Electrical Engineering in Switzerland.—It is reported that the Rheinfelden Electricity Company, of Rheinfelden, has contracted to supply the necessary electrical energy required by a German-French company which intends to establish large works near Rheinfelden for the production of calcium carbide.

Appointment Vacant.—The Electrical Committee of Bristol want a charge engineer. See our "Official Notices" for particulars.

Silex.—Oscar Mohle, in the New York *Electrical Engineer*, describes "Silex," which he terms the ideal fireproof insulation, and which has been used for "the first absolutely fireproof system" of vertical mains for electrical conductors at a house on Fifth Avenue, New York. Silex (di-oxide of silicon) controls electric currents of the highest tension. It has, we are told, an extraordinarily high fire resisting quality, fusing only at the temperature of the oxy-hydrogen flame, and is practically a non-conductor of heat. It is non-hygroscopic, and absolutely proof against the action of water. Its specific inductive capacity is extremely low, being from 10 to 250 per cent. less than any other insulation now in use. In the building mentioned steel tubes contain three No. 0 copper wires imbedded in finely pulverised silex, solidly packed, so as to prevent any possible change in their relative positions, either through careless handling in transportation or installation. These are connected with the street service at the house line in the cellar, continuing along the ceiling to the elevator shaft, and thence rising to the top of the building. The lengths in the cellar are joined by a special coupler, allowing ample room for connecting conductors, which is then thoroughly packed with silex. At each floor the tube passes through a junction or outlet box, in one side of which connections are made, and the space likewise filled in with silex and sealed. The other side of the box is properly slate lined and provided with binding posts for safety fuses of branch circuits. This, in brief, describes the component parts of the silex system of mains.

Interior Conduits.—We learn that arrangements have been made for the manufacture, near Birmingham, of interior conduits as made by the Armorite Interior Conduit Company, of Detroit, Mich. It is stated that the necessary conduit machinery has been ordered in the United States to be shipped over here. Mr. R. H. Kilby, an English iron manufacturer, who has just returned home, has full authority from the company to establish the works, which will be located within carting distance of the plant which will supply the iron tube used in making the armorite conduit.

Platinum.—The American technical journals have recently contained articles regarding a large shipment of platinum from Colombia to a Newark firm of platinum refiners, which contained what is believed to be the largest ever exhibited in America. It measures roughly $3 \times 2 \times \frac{3}{4}$ inches, and weighs nearly 2 lbs. It is stated that platinum was first discovered in a Spanish mine of South America, early in the sixteenth century, from which source it received its name "platina del Pinto" (little silver from the river Pinto). The ore is now found in various parts of the world, but the richest deposits are those of the Ural mountains, which have been worked under the supervision of the Russian Government since 1828. Commercial platinum is produced from alluvial deposits at depths of 6 to 40 feet. The sand and gravel of former river beds is screened and washed a number of times to effect the separation of the ore. The yield of ore per ton of sand seldom exceeds 6 grams. There is a Government tax imposed in Russia upon platinum ore, and we understand that possession thereof without a proper licence is when discovered, rewarded with imprisonment and confiscation. Our readers are well aware of the enormous assistance that this metal has rendered to the development of electric lighting in its employment in the incandescent lamp. It was early used as the light-giving body of the lamp, but subsequently yielded this position to carbon because of the latter's higher electrical resistance, higher fusion point and lessened cost. Although now occupying a less prominent position in the modern lamp it is nevertheless considered as essential in the construction of a successful lamp. Many devices have been tried to avoid its use but without commercial success. Radical changes in the construction of incandescent lamps have reduced the consumption of platinum per lamp enormously, but on the other hand the production of lamps has increased in greater proportion, and the aggregate consumption is greater than ever before in that industry. Almost every branch of electrical industry makes every year a heavy demand upon the limited supply. The latest application is due to Röntgen's discovery that certain invisible rays of energy, when allowed to fall upon one of the double salts of platinum (barium-platino-cyanide) render the salt luminous, so that a screen of paper covered with this salt and exposed to the action of Röntgen rays serves for the production thereon of a shadow picture of many objects of variable density, which may be interposed between the screen and the source of the Röntgen rays. Metallic platinum is also a most important factor in the construction of Röntgen ray apparatus, both as a means of conveying electric energy into the vacuum chamber and as a source of excitation of the rays.

Institution of Junior Engineers.—The members will visit the Blackwall Tunnel works on Saturday, May 1st, at 3 p.m. On Friday next, May 7th, at the Westminster Palace Hotel, a paper by Mr. L. G. Ferriera, member (N. L. Ry.), on "Electrical Railway Signalling," will be read and discussed.

Advantage of Electric over Steam Locomotives in Starting.—Perhaps in no other way, says the *Street Railway Review*, is the superiority of electric locomotion better shown than in the controlling mechanism for starting and stopping. The controller and reversing handles are very easily and quickly manipulated, when compared with the corresponding appliances on a steam locomotive. The motors respond almost instantly, and give such an even acceleration to the train, that there are no great strains in the cars and draw bars. The quick-acting air-brake which is attached to the electric locomotives permits of higher rates of speed than the steam brake on many steam switch engines. In steam engines there is always a noticeable delay between the time when the throttle valve is opened and the pistons begin to move. This is often the cause of serious delays, for while each stop and start causes only a small loss of time, yet the aggregate amounts to a great deal. Another point worthy of mention is that when idle an electric locomotive absorbs no power, while a steam engine consumes as much coal just keeping steam up as it would to run at a constant speed of six miles an hour. In switching yards either for making up trains or moving cars in manufacturing districts, the advantages of electric locomotives are so apparent that their use will not be long disregarded. But as E. H. Mullin points out in *Cassier's Magazine*, some alterations are needed in the present designs. The cab should be a circular conning tower, from which the operator could see in all directions, and in this should be placed the handles of the controller, reversing lever and air brake valve. The contact to the trolley wire should be designed to run equally well in either direction without the necessity of its being pulled around by hand. With these improvements electric locomotives should find application in many localities, making a saving in time and cost of handling freight.

Foreign Competition in the Netherlands.—Information as to the extent to which Germany is competing with Great Britain for trade in the Netherlands is given in a report by Mr. W. Robinson to the Foreign Office. The Netherland population, we learn with gratification, has always shown a preference for quality over cheapness, hence British manufactures have fairly held their own in the face of bitter competition from a cheaper imitation. In respect to the engineering and machinery trades, Mr. Robinson finds that the general complaint is that British iron and steel manufacturers, engine and tool makers, are so full of work, that it is impossible to get foreign orders punctually executed, while in this respect Germany is much more prompt in deliveries. The chief obstacles to an extension of British trade in the Netherlands are stated as follows:—

1. The greater facilities given by German manufacturers in the way of credit. Most British houses of standing adhere strictly to the system of cash against shipping documents, and are inclined to turn a deaf ear to any complaint in respect of quality, &c., after the goods have been received. I find it universally stated that German manufacturers are more liberal in these respects. 2. The system of weights and measures in Great Britain. So long as Great Britain adheres to her present system, her manufacturers will always be greatly handicapped in dealing with the Continent, where the decimal system universally prevails. 3. The want of classification of British goods, more especially in the iron and steel trades. This classification, moreover, would now have to adapt itself entirely to the continental system of decimal weights and measures. In Germany, the organisation of manufacturers and engineers in respect of classification appears to be far in advance of Great Britain. 4. The existence of the protective system in Germany, the invariable tendency of which is to unduly depress the prices charged for exported goods, in order to maintain a higher range of prices at home.

We refer our readers to the report as published by the Foreign Office, or to some extracts in a recent issue of the *Engineer*.

NEW COMPANIES REGISTERED.

Paul's Animatographe, Limited (52,215).—Registered April 21st, with a capital of £60,000 in £1 shares, to adopt an agreement with R. W. Paul, and to carry on the business of caterers for public entertainments and exhibitions, motor car, waggon and carriage builders, electricians, engineers, photographers, film and negative manufacturers, printers, bill posters, advertising contractors, &c. The subscribers (with one share each) are:—R. W. Paul, 44, Hatton Garden, E.C., electrician; G. F. Taylor, Gower House Hotel, W.C., gentleman; M. L. Taylor, 5, Marquis Road, Camden Town, clerk; A. L. Paul, 15, Grenville Street, Brunswick Square, W.C., accountant; W. V. Hunt, 15, Stanley Road, Wimbledon, electrical engineer; F. E. Gambrell, Allfarthing Lane, Wandsworth, electrician; J. H. Martin, 3, Ribblesdale Road, Hornsey, photographer. The number of directors is not to be less than three nor more than seven; the first are J. Hollingshead, N. Maskelyne, A. Rayment, and R. W. Paul; qualification, £100; remuneration, £100 each per annum, or 10 per cent. of the net profits divided, with a maximum of £800 per annum. Registered by R. Miller & Co., St. Stephen's Chambers, Telegraph Street, E.C.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Scarborough Electric Supply Company, Limited (37,569).—This company's annual return was filed on March 19th, when 4,000 were taken up out of a capital of £50,000 in £10 shares. £9 per share has been called on 3,434 of these, and £4 per share on the others, and £33,196 has been paid. £26 has been paid in advance of calls.

Sheffield Electric Light and Power Company, Limited (36,351).—This company's capital has just been increased from £98,000 in £5 shares, to £280,000 by the creation of 26,000 new shares of £5 each.

Westminster Electric Supply Corporation, Limited (27,061).—This company's annual return was filed on March 18th, when 68,000 shares were taken up out of a capital of £400,000, and the full amount called and paid.

CITY NOTES.

The Oriental Telephone and Electric Company, Limited.

The third ordinary general meeting of the shareholders of this company was held on Tuesday last at the Cannon Street Hotel, Mr. William Addison, the chairman, presiding.

Mr. A. B. Chalmers (the secretary) having read the advertisement convening the meeting, the directors' report and accounts were taken as read.

The Chairman, in proposing the adoption of the report, said:—Gentlemen, you will see by the report that after paying a 5 per cent. dividend for the past year, we are also able, out of the revenue for that period, to write off £1,427 5s. to the credit of the Colombo Exchange suspense account, leaving now only £1,000 to the debit of that account, and that we carry forward a balance of £629 14s. 3d. Had it not been for the arbitrary and inequitable action of the Ceylon Government in appropriating our business without adequately compensating this company, even for the capital expended, not to mention compensation for the goodwill, the board would have been able to apply nearly £1,500 to the establishment of a reserve fund, such as we had in the old company, which was available for the equalisation of dividends and other purposes. While on this subject it may be as well to mention, in case there are any new shareholders present, that owing to the reconstruction of the old company, the reserve fund then existing can now only be applied to capital purposes. The electric light business has still resulted in a loss. I may say that part of that can hardly be called a loss, as the outlays at Bombay, Madras, and Rangoon in negotiations for business will, I hope, eventually be to our advantage. I need hardly remind you of the severe suffering in India for months past from famine and plague, which, I am sorry to say, unhappily still prevails and is likely to last for some time to come. Naturally these trials have greatly interfered with business generally, and as we have so large an interest in that country your directors thought it right to contribute a sum of 50 guineas to the Indian Famine Mansion House Fund. We feel sure sympathy with our fellow subjects in India will make you heartily approve of our action.

Mr. T. Lloyd seconded the motion, and the report was carried without discussion.

Mr. Sr. John Ackers proposed the re-election of Mr. Henry Grëwing as a director.

Mr. Lloyd seconded the resolution, which was carried, and on the motion of Mr. Frost, Mr. Addison was also re-elected to the board.

A vote of thanks to the chairman for presiding closed the proceedings.

Eastern Extension Telegraph Company, Limited.

The half-yearly general meeting of the Eastern Extension, Australasia, and China Telegraph Company, Limited, was held on Wednesday, at Winchester House, the Marquis of Tweeddale presiding.

The Chairman, in moving the adoption of the report, said that the increase in expenditure was exceptional in character, largely due to the duplicating of cables and the providing of machinery at Singapore for the renewal of cables on the spot. Comparing the figures of 1896 and 1895, the receipts amounted in the former to £649,319, being an increase of £63,599. Seeing that during 1896 there had been a great reduction in the charges for through rates, the increase of revenue was most gratifying. The large increase in the revenue was in the main due to the extraordinary development of gold mining in West Australia. There would be further reduction in the through rates to China. The general reserve fund had been increased to £729,193, and the whole was invested in securities of the highest class. Several of the old cables were showing signs of weakness, and rendered it necessary that renewals should be made during the next two years. Since the close of the year they had come to an agreement with the Spanish Government for a cable in connection with the Philippine Islands, which would include the towns of Iloilo and Manilla. They had also agreed to supply the Dutch Government with two short cables. A commission has been inquiring into the feasibility of a cable connecting Canada and the United States, China and Australia, and he thought there would be no insurmountable difficulties standing against its accomplishment. He believed such a cable was within measurable realisation.

The report was adopted, and the retiring directors, the Hon. George Peel and Mr. F. A. Bevan, were re-elected, as well as the retiring auditors.

Indo-European Telegraph Company, Limited.

The annual general meeting of the Indo-European Telegraph Company, Limited, was held on Wednesday at Winchester House, Mr. J. H. Tritton presiding.

The Chairman, in moving the adoption of the report, said that there had been no great vicissitudes or changes in the undeviating and quietly prosperous condition of their affairs, their expenses and receipts for 1896 being almost identical with those of the previous year. Nothing had occurred at the Buda-Pesth Conference to interfere seriously with their revenues. Certain concessions favourable to those using the wires had been made, which would no doubt be satisfactory, while well within the means of the company. In fact, the reductions of rates made at former conferences were so drastic and far-reaching, that the necessity for repose and gradual recoupment was forced upon the attention of all those interested. They had introduced into use a high-speed Wheatstone mechanical transmitter, which, with the duplex arrangements already in use, should enable their wires to deal with any increase of business that might be likely to arise. The total sum available for distribution was £60,204, out of which £10,000 was placed to the reserve.

Mr. C. Holland seconded the motion, which was agreed to.

The West Coast of America Telegraph Company, Limited.—This company will be prepared on Friday, April 30th, 1897, at their office, Winchester House, 50, Old Broad Street, E.C., to deliver scrip representing first mortgage debentures of that company, bearing interest at the rate of 4 per cent. from January 1st, 1867 (the principal and interest of which is guaranteed by the Brazilian Submarine Telegraph Company, Limited, in accordance with the terms of an agreement dated April 20th, 1897), in exchange for debentures of an equal nominal amount of the West Coast of America Telegraph Company, Limited (in liquidation), with all unpaid coupons attached, or to pay to the holders of the said debentures the principal due on the said debentures and interest to the said April 30th.

The Western and Brazilian Telegraph Company, Limited.—The directors have decided that after placing £5,000 to the reserve fund, they will, subject to audit, recommend at the forthcoming meeting a dividend at the rate of £2 per cent. per annum (3s. per share), free of income-tax, for the six months ended December 31st last, carrying forward £6,406.

Royal Electric Company of Montreal, Limited.—Messrs. Coates, Son & Co., are authorised to receive, until to-day, Friday, subscriptions for a further issue of 2,500 shares of $100 each in the Royal Electric Company of Montreal, Canada, which has an authorised share capital of $1,500,000, of which $1,200,000 has been subscribed. The price of issue is $140, or, at par of exchange, £28 15s. 6d. per $100 share. It is stated that quarterly dividends have been regularly paid by the company for some years at the rate of 8 per cent. per annum, which rate is equivalent, at the price of issue, is over £5 14s. per cent. per annum.

TRAFFIC RECEIPTS.

The City and South London Railway Company. The receipts for the week ending April 25th, 1897, were £938; week ending April 26th, 1896, £889; increase, £39; total receipts for half-year, 1897, £17,612; corresponding period, 1896, £16,149; increase, £1,463.

The Cuba Submarine Telegraph Company. The traffic receipts for the month of January were £3,594, as compared with £4,843 in the corresponding month of last year.

The Liverpool Overhead Railway Company. The receipts for the week ending April 25th, 1897, amounted to £1,770; corresponding week last year, £1,168; increase, £602.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending April 23rd, 1897, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £1,905.

SHARE LIST OF ELECTRICAL COMPANIES.

TELEGRAPH AND TELEPHONE COMPANIES.

Present Issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1894.	1895.	1896.	Closing Quotation, April 21st.	Closing Quotation, April 28th.	Business done during week ended April 28th, 1897. Highest.	Lowest.
173,400£	African Direct Teleg., Ltd., 4 % Deb.	100	4 %	4 %	...	100 —104	100 —104	...	...
25,000	Amazon Telegraph, Limited, shares...	10	...	...	...	4½— 5½	4½— 5½	...	...
1,612,880£	Anglo-American Teleg., Ltd.	Stock	£2 2s.	£2 9s.	£2 13s.	49 — 52	49 — 52xd	50½	49
2,993,560£	Do. do. 6 % Pref.	Stock	£4 4s.	£4 18s.	£5 6s.	93½ - 94½	93½— 94½xd	94½	93⅝
2,993,560£	Do. do. Defd.	Stock	...	...	...	7⅞— 8	7⅞— 8	...	...
130,000	Brazilian Submarine Teleg., Ltd.	10	7 %	7 %	...	14⅝— 15½	14⅝— 15½	15 1/16	14⅝
75,000£	Do. do. 5 %, Debs., 2nd series, 1906	100	5 %	5 %	...	113 —117	113 —117	...	...
44,000	Chili Telep., Ltd., Nos. 1 to 44,000	5	2½%	4 %	...	3¼— 3⅜	3¼— 3⅜	...	...
13,000,000$	Commercial Cable Co.	$100	7 %	7 %	7 %	162 —167	162 —167	...	...
40,000£	Do. Do. Sterling 500 year 4% Deb. Stock Red.	Stock	...	...	...	97 — 99	97½— 98½	98½	97⅝
224,850	Consolidated Telep. Const. and Main., Ltd.	10/-	1½%	1½%	...	3/16— 5/16	3/16— 5/16	...	...
16,000	Cuba Teleg., Ltd.	10	8 %	8 %	8 %	10 — 11	10 — 11	...	...
6,000	Do. 10 % Pref.	10	10 %	10 %	10 %	19 — 20	19 — 20	...	...
12,931	Direct Spanish Teleg., Ltd.	5	4 %	4 %	4 %	3½— 4½	3½— 4½	...	...
6,000	Do. do. 10 % Cum. Pref.	5	10 %	10 %	10 %	10 — 10½	10 — 10½	...	...
30,000£	Do. do. 4½ % Debs. Nos. 1 to 6,000	50	4½%	4½%	4½%	105 —108%	105 —108 %	...	...
60,710	Direct United States Cable, Ltd.	20	2 %	2½%	2½%	8¾— 9¼	8½— 9	...	...
400,000	Eastern Teleg., Ltd., Nos. 1 to 400,000	10	6½%	6½%	...	17 — 17½	17 — 17½	17½	16⅞
70,000	Do. 6 % Cum. Pref.	10	6 %	6	...	18 — 19	18 — 19	18½	...
102,100£	Do. 5 % Debs., repay. August, 1899	100	5 %	5 %	...	103 —106	103 —106	...	...
1,297,837£	Do. 4 % Mort. Deb. Stock Red.	Stock	4 %	4 %	...	127 —130	126 —129 xd	126½	...
250,000	Eastern Extension, Australasia and China Teleg., Ltd.	10	7 %	7 %	7 %	17⅞— 18¼	18 — 18½	18⅜	18
54,100£	Do. 5 % (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	5 %	5 %	5%	100 —104	100 —104	...	...
194,300£	Do. do. Bearer, 1,050—3,975 and 4,327—6,400	100	5 %	5 %	5%	101 —104	101 —104	...	...
320,000£	Do. 4 % Deb. Stock	Stock	4 %	4 %	4%	127 —130	127 —130	128½	...
80,600£	Eastern and South African Teleg., Ltd., 5 % Mort. Deb. 1900 redeem. ann. drgs., Reg. Nos. 1 to 2,343	100	5 %	5 %	5%	100 —104	100 —104	...	...
107,600£	Do. do. do. to bearer, 2,344 to 5,500	100	5 %	5 %	5%	101 —104	101 —104	101⅛	...
300,000£	Do. 4 % Mort. Debs. Nos. 1 to 3,000, red. 1909	100	4 %	4 %	4%	107 —110	107 —110	...	...
200,800£	Do. 4 % Reg. Mt. Debs. (Mauritius Sub.) 1 to 8,000	25	4 %	4 %	4%	109 —112 %	109 —112 %	...	...
180,227	Globe Telegraph and Trust, Ltd.	10	4½%	4½%	...	11 — 11½	11 — 11½xd	11¼	11 1/16
180,042	Do. do. 6 % Pref.	10	6 %	6 %	...	17 — 17½	17 — 17½xd	17⅜	17
150,000	Great Northern Teleg. Company of Copenhagen	10	8⅝%	10 %	10 %	24 — 25	24 — 25	24 1/16	...
180,000£	Do. do. do. 5 % Debs.	100	5 %	5 %	5 %	102 —105	102 —105	...	...
17,000	Indo-European Teleg., Ltd.	25	10 %	10 %	10 %	55 — 58	55 — 58	...	...
100,000£	London Platino-Brazilian Teleg., Ltd. 6 % Debs.	100	6 %	6 %	6%	107 —110	107 —110	...	...
28,000	Montevideo Telephone 6% Pref., Nos. 1 to 28,000...	5	4 %	4 %	...	2 — 2½	2 — 2½	...	...
484,597	National Teleph., Ltd., 1 to 484,597	5	5 %	5½%	5½%	6⅜ - 6⅝	6¼ - 6½	6 9/16	6 5/16
15,000	Do. 6 % Cum. 1st Pref.	10	6 %	6 %	6 %	15 — 17	15 — 17	15⅜	...
15,000	Do. 6 % Cum. 2nd Pref.	10	6 %	6 %	6 %	15 — 17	15 — 17	...	...
119,234	Do. 5 % Non-cum. 3rd Pref., 1 to 119,234	5	5 %	5 %	5 %	6 — 6½	6 — 6½	6	...
1,100,000£	Do. 3½ % Deb. Stock Red.	Stock	3½%	3½%	3½%	102 —105	102 —105	103⅜	102½
171,504	Oriental Teleph. & Elec., Ltd., Nos. 1 to 171,504, fully paid	1	4½%	5 %	3½%	⅝ - ¾	⅝ - ¾xd	...	...
100,000£	Pacific and European Tel., Ltd., 4 % Guar. Debs, 1 to 1,000	100	4 %	4 %	4%	107 —110	107 - 110	...	...
11,839	Reuter's Ltd.	8	nil	5 %	...	7 — 8	7 — 8	...	...
3,381	Submarine Cables Trust	Cert.	...	...	...	136 —141	136 —141	138½	...
58,800	United River Plate Teleph., Ltd.	5	3 %	4 %	...	3 — 3½	3 — 3½	3 7/16	...
146,733£	Do. do. 5 % Debs.	Stock	5 %	5 %	...	100 —105	100 —105	...	...
15,509	West African Teleg., Ltd., 7,501 to 23,109	10	nil	4 %	...	5 — 6	5 — 6	...	...
238,300£	Do. do. do. 5 % Debs.	100	5 %	5 %	...	101 - 104	101 —104	...	...
39,000	West Coast of America Teleg., Ltd.	10	nil	nil	...	⅜ — 1½	⅜ 1½	⅜	...
150,000£	Do. do. do. 8 % Debs., repay. 1902	100	8 %	8 %	...	103 - 108	103 108	104	...
54,248	Western and Brazilian Teleg., Ltd.	15	3 %	3 %	2 %	7½ - 8	7½— 8	...	...
33,129	Do. do. do. 5 % Pref. Ord.	7½	5 %	5 %	...	6¼ - 6⅝	6¼ - 6⅝	6⅝	...
33,129	Do. do. do. Def. Ord.	7½	1 %	1 %	...	1½ - 2	1½ - 2	...	...
165,280£	Do. do. do. 6 % Debs. "A," 1880 Red.	100	6 %	6 %	...	112 —116	112 - 116	...	...
206,400£	Do. do. do. do "B," do.	100	6 %	6 %	...	109 —113	109 —113	...	...
88,321	West India and Panama Teleg., Ltd.	10	⅛%	⅛%	...	⅝— 1½	⅝— 1½	...	...
34,563	Do. do. do. 6 % Cum. 1st Pref.	10	6 %	6 %	...	11 — 11½	11 — 11½	...	...
4,569	Do. do. do. 6 % Cum. 2nd Pref.	10	6 %	6 %	...	9½— 10½	9½— 10½	...	...
88,800£	Do. do. 5 % Debs. No. 1 to 1,808	100	5 %	5 %	...	107 —110	107 —110	...	...
1,777,000$	Western Union of U. S. Teleg., 7 % 1st Mort. Bonds	$1000	7 %	7 %	7%	107 —112	107 —112	...	...
164,300£	Do. do. 6 % Ster. Bonds.	100	6 %	6 %	6%	100 —105	100 —105	...	...

ELECTRICITY SUPPLY COMPANIES.

30,000	Charing Cross and Strand Electy. Supply	5	4½%	5 %	6 %	10½ - 11⅛	10½ - 11⅛	11⅛	10⅝
10,277	*Chelsea Electricity Supply, Ltd., Ord., Nos. 1 to 10,277	5	5 %	5 %	5 %	8⅞ - 9¼	8⅞— 9¼	9⅛	...
60,000	Do. do. do. 4½ % Deb. Stock Red.	Stock	...	4½%	4½%	112 —115	112 —115	...	...
40,000	City of London Elec. Lightg. Co., Ltd., Ord. 40,001—80,000	10	5 %	5 %	7 %	22 — 23	22 — 23	22⅝	22 1/16
40,000	Do. do. 6 % Cum. Pref., 1 to 40,000	10	6 %	6 %	6 %	16½ - 17½	16½— 17½	17¼	16 15/16
300,000	Do. 5 % Deb. Stock, Scrip. (iss. at £115) all paid	...	5 %	5 %	5 %	132 —136	128 —133	...	...
22,475	County of Lond. & Brush Prov. E. Ltg. Ltd., Ord. 1—22,475	10	...	nil	nil	12 — 12½	12 — 12½	12¼	12
20,000	Do. do. do. 6% Pref., 40,001—50,000	10	...	6 %	6 %	14½ - 15	14½— 14⅝	14¼	14⅛
10,000	Do. do. do. iss. at 2 pm., all paid	10	...	...	..	14½ - 14⅝	14½— 14⅝	14⅝	14½
10,000	House-to-House Elec. Light Supply, Ord., 101 to 10,100	5	...	...	...	7½— 7⅝	7½— 7⅝	7⅝	7½
49,900	*Metropolitan Electric Supply, Ltd., 101 to 50,000	10	3 %	4 %	...	16½ — 17½	16½ — 17½	17 1/16	16⅝
12,500	Do. Ord., 50,001—62,500, iss. at £2 prem.	10	...	...	...	12½ - 13½	12½— 13½	13½	13 1/16
150,000£	Do. 4½% first mortgage debenture stock	..	4½%	4½%	...	120 —124	120 —124	122	120
5,452	Notting Hill Electric Lightg. Co., Ltd.	10	1 %	2 %	4 %	12 — 13	12½ — 13½	13	12⅝
19,980	*St. James's & Pall Mall Elec. Light Co., Ltd., Ord., 101-20,080	5	6½%	7½%	10½%	15 — 16	15 — 16	15⅞	15½
20,000	Do. do. 7 % Pref., 20,081 to 40,080	5	7 %	7 %	7 %	9½ - 10½	9½— 10½	...	...
50,000	Do. do. 4 % Deb. stock Red.	Stock	...	...	...	104 —107	104 —107	...	...
67,900	*Westminster Electric Supply Corp., Ord., 101 to 60,000	5	5 %	7 %	9 %	13½— 14½	13½— 14½	14	13⅝

* Subject to Founder's Shares. † Quotations on Liverpool Stock Exchange.

‡ Unless otherwise stated all shares are fully paid. ‖ Dividends paid in deferred share warrants, profits being used as capital.

§ Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

SHARE LIST OF ELECTRICAL COMPANIES—*Continued.*

ELECTRICAL RAILWAY, MANUFACTURING, AND INDUSTRIAL, COMPANIES.

Present Issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1894.	1895.	1896.	Closing Quotation, April 21st.	Closing Quotation April 28th.	Business done during week ended April 28th, 1897. Highest.	Lowest
90,000	Brush Elecl. Enging. Co., Ord., 1 to 90,000...	5	2½%	...	...	¾ — 1	⅞ — 1⅛	...	...
90,000	Do. do. Non-cum. 6 % Pref., 1 to 90,000	2	3 %	...	...	1¼ — 1½	1⅜ — 1⅝	1½	1⅞
125,000§	Do. do. 4½ % Perp. Deb. Stock... ...	Stock	4½%	...	...	104 —108	104 —108	...	...
76,770	Do. do. 4½% 2nd Deb. Stock Red. ...	Stock	...	...	...	95 — 99	95 — 99	...	...
9,104	Central London Railway, Ord. Shares	10	...	...	...	9½ — 10	9½ — 10	10	...
207,649	Do. do. do. £6 paid	10	...	...	...	5½ — 6	5½ — 6	5 13/16	...
630,000§	City and South London Railway	Stock	1½%	1 3/16%	1 9/16%	59 — 61	59 — 61	...	...
28,180	Crompton & Co., Ltd., 7 % Cum. Pref. Shares, 1 to 28,180	5	*nil*	*nil*	...	1⅝ — 2¼	1⅝ — 2¼	..	...
89,261	Edison & Swan United Elec. Lgt., Ltd., "A" shrs, £3 pd. 1 to 89,261	5	5 %	5 %	...	1⅝ — 2¼	1⅝ — 2¼	1⅝	...
17,139	Do. do. do. "A" Shares 01—017,139	5	5 %	5 %	...	3 — 4	3 — 4	...	...
100,000	Do. do. do. 4½% Deb. Stock Red. ...	Stock	4½%	4½%	...	106 —110	105 —110	...	...
110,000	Electric Construction, Ltd., 1 to 110,000	2	*nil*	5 %	...	1⅛ — 1⅜	1⅛ — 1⅜	...	...
12,845	Do. do. 7 % Cum. Pref., 1 to 12,845 ...	2	7 %	7 %	...	2⅜ — 3¼	2⅜ — 3¼	...	...
91,195	Elmore's Patent Cop. Deposg., Ltd., 1 to 70,000	2	*nil*	...	...	¾ — 1	¾ — 1	15/16	...
69,385	Elmore's Wire Mfg., Ltd., 1 to 69,385, issued at 1 pm. ...	2	*nil*	...	...	¼ — ½	¼ — ½	...	...
9,600§	Greenwood & Batley, Ltd., 7 % Cum. Pref., 1 to 9,600 ...	10	*nil*	10½%	...	11 — 13	11 — 13	...	...
10,000	Henley's (W. T.) Telegraph Works, Ltd., Ord.	10	6 %	8 %	10 %	19 — 20	18½ — 19½	...	...
3,000	Do. do. do. 7% Pref.	10	7 %	7 %	7 %	18½ — 19½	18½ — 19½	19¼	...
50,000	Do. do. do. 4½ Mort. Deb. Stock	Stock	...	4½%	4½%	107 —112	108 —113	...	...
56,000	India-Rubber, Gutta Percha and Teleg. Works, Ltd. ...	10	10 %	10 %	10 %	20½ — 21½	20½ — 21½	21½	20¾
300,000	Do. do. do. 4 % 1st Mort. Debs.	100	...	...	...	104 —107	104 —107	...	...
37,500	†Liverpool Overhead Railway, Ord.	10	1½%	2⅞%	2⅞%	12 13/16 — 12 15/16	12 13/16 — 12 15/16	...	...
10,000	† Do. do. Pref., £10 paid	10	5 %	5 %	5 %	16⅛ — 16⅝	15 — 15½	...	...
37,350	Telegraph Constn. and Maintce., Ltd.	12	20 %	15 %	15 %	34 — 37	34 — 37	35½	34¾
150,000	Do. do. do. 5 % Bonds, red. 1899	100	5 %	5 %	5 %	103 —106	103 —106	...	...
54,000§	Waterloo and City Railway, Nos. 1 to 54,000, £8 paid ...	10	...	...	...	10¾ — 11¼	10¾ — 11¼	11⅛	10 15/16

Quotations on Liverpool Stock Exchange. ‡ Unless otherwise stated all shares are fully paid. ¶ Last dividend paid was 50% for 1890.
Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.
Crompton & Co.—The dividends paid on the ordinary shares (which have not a Stock Exchange quotation), are as follows: 1892—0%; 1891—7%; 1890—9%

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Birmingham Electric Supply Company, Ordinary of £5 (£4 paid), 7⅞, £5 (fully paid) 9⅛.

Electric Construction Corporation, 6 % Debentures, 103—106.

House-to-House Company, 7 % Preference, of £5, 9¼—9⅜.

Do. do. 4½% Debentures of £100, 109 –111.

Kensington and Knightsbridge Electric Lighting Company, Limited, Ordinary Shares £5 (fully paid) 11⅜—12¼; 1st Preference Cumulative 6 %, £5 (fully paid), 8—8½. Dividend, 1896, on Ordinary Shares 7 %.

London Electric Supply Corporation, £5 Ordinary, 1⅜ –1⅝.

Yorkshire House-to-House Electricity Company. £5 Ordinary Shares fully paid, 8½—9. Dividend for 1896—6 %.

* From Birmingham Share List.

Bank rate of discount, 2½ per cent. (April 8th 1897).

REVIEWS.

The Hydro-Electric Methods in Medicine.—By W. S. Hedley, M.D. London: H. K. Lewis.

The electric bath appears to be the most successful of all the methods of applying electricity to the healing art. It has been shown, repeatedly by well-qualified physicians that treatment by the electric bath is capable of curing certain diseases of the nervous system and many diseases due to failure or perversion of nutrition. There is apparently, yet, much to learn about the management and application of the electric bath. Dr. Hedley's little book gives an excellent popular account of what is already known on the subject. Sometime ago, the continuous current was the favourite form in which electricity was applied to the patient in the bath, but the alternating current, as supplied by our central stations is now most generally used. The recent experiments of Gautier and Sarat appear to have contributed greatly to effect this revolution. It comes to be a very important question, in the study of the electric bath, to ascertain the electric resistance of the human body. When the body of the patient is immersed in the bath, and a current is sent through the composite conductor formed by the bath water and the body, the proportion of current which passes through the body depends, of course, on the ratio of its resistance to that of the water. Dr. Hedley has attacked this problem in his chapter on the "Physics of the Hydro-Electric Bath." It is by no means a simple problem, and Dr. Hedley's method, though in some points open to adverse criticism, is, on the whole, rational and scientific. Dr. Hedley considers the body as forming a shunt circuit with the water in the bath. He estimates the combined resistance of the body and the water, by measuring the volts and amperes at the terminals, and then the resistance of the water alone. The difference of the conductivities of these two conductors, is taken as the conductivity of the human body. The figures which Dr. Hedley obtains do not, however, give one much confidence in this method; these figures vary in round numbers from 300 to 800 ohms. Dr. Hedley points out several sources of error in these measurements, the difference in the inclination of the body, the back E.M.Fs. produced by polarisation, &c., and he appears to think that the latter at least cannot be eliminated. Kohlrausch discovered, in 1880, a method of measuring the true ohmic resistance of an electrolyte by means of alternating currents, and a bridge with a telephone. This method is simple, and has been generally accepted by physicists as reliable, yet it does not seem to satisfy Dr. Hedley. Dr. Hedley prefers to estimate the apparent resistance by mixing up the back E.M.F. with the ohmic resistance. No estimate of the resistance of the body of much scientific value is ever likely to be obtained by this method. Another factor that ought to be taken into account is the variation in the resistance of water due to the solution of even small quantities of salts. The specific resistance of the liquid in the bath may vary considerably during use owing to this cause. Owing to variation of the section and probably also the specific conductivity of the human body, along its length, the only accurate method of getting at a correct result would be by a summation of the resistances of short sections of sensibly uniform conductivity. Notwithstanding these adverse criticisms, Dr. Hedley's book is on the whole very sound from the electrical standpoint, and appears to us to be a very complete and up-to-date treatise on this promising method of electro-medical treatment.

Hydraulic Machinery. By R. G. Blaine. London: E. and F. N. Spon, 1897.

The author writes this book under the belief that there is a need for it, and we are disposed to agree with him that the literature of hydraulic machinery is scanty. At the same time, we have found that questions of hydraulics have formed stumbling blocks even for engineers from whom better things might be expected. Over and over again we have met engineers who were impressed with the idea of there being a great pressure upon a pipe leading out of a *large* tank, as though

any other factor than tank depth could influence the stress on the pipe. To talk of water being incompressible is wrong. It is practically so for purposes of hydraulics, but it is compressible to the extent of $\frac{1}{20000}$th for each atmosphere of difference of pressure. This is quite a considerable fraction of the original volume. It means that with only some 15 lbs. per square inch of additional pressure we might push about a gallon of water into a mile of full 12-inch pipe. In a work of this description it would be impossible not to have an enormous amount of compilation. Such, indeed, is a large part of the book, but the compilation is good. The object of the writer seems to have been to consider every imaginable variety of hydraulic machine, to explain the principles underlying the construction and operation, and to show in what way theory may be departed from to secure practice which will be economical, as well as to illustrate everything with one or more examples. Thus we find various turbines, hydraulic lifts direct and indirect, centrifugal pumps, hydraulic jacks and presses, water pressure engines, the machinery of swing bridges, and canal lifts, railway capstans, jet propellors, gun machinery for warships, brakes, dock gate machinery, cranes, rams, and numerous other hydraulic appliances illustrated generally and in detail. The book is not, however, a mere catalogue of machines in any sense, but a good practical work, the various devices for securing a given end being well described and their defects pointed out. Thus, in lifts for buildings, the apparently safer direct-acting lift is shown to be not so under the conditions possible in practice. Questions of efficiency and economy find their place, and the author has been successful in producing a book which contains between two covers a very good aid to the user of water in all manner of power appliances. There are also abundant references to original papers for those who may desire fuller information than can here be afforded.

Practical Electrical Measurements. By Ellis H. Crapper. London: Whittaker & Co., 2, White Hart Street, Paternoster Square.

Like many other books of the kind this work is a development from the notes and exercises of a technical teacher who, having his own particular style of teaching, embodies this in a text-book for his students. Mr. Crapper is lecturer in electrical engineering at the Sheffield Technical School. The book is very practical in its style, and the use of numerical examples is a good feature. Mr. Crapper, for example, explains the whole process of obtaining "H" from beginning to end by actual experimental value, which can leave the student in no doubt as to the various steps to be followed. This practice might, with advantage, have been extended. The instruments described are not of an elaborate form, but are mostly such as a student could manufacture for himself, which is a useful thing. It would be an advantage if answers to the exercises at the end of the chapters were given. In describing the mirror galvanometer Mr. Crapper does not explain that the angular movement of the beam of light is double that of the needle, in fact, his explanation would almost lead one to suppose that this was not the case, and is decidedly misleading. In fig. 36, page 80, a diagram of the Post Office Bridge has the "I.N.F." gap in the wrong position, and the resistances are not of the numerical values adopted by the Post Office. Amongst the tables at the end of the book is a rather elaborate one of natural sines, though its use is not obvious. Taking the book as a whole it is a very serviceable one.

Lectures.—At a meeting of the Newcastle Insurance Institute last Friday, Mr. Frank Broadbent, A.Inst.E.E., &c., delivered his second lecture on "Electrical Distribution." The various systems of wiring were described and illustrated by means of diagrams, and samples of wiring accessories, cables, casing, interior conduit, &c., were shown. A dynamo and motor were exhibited in operation, the one being driven by the other, and the energy measured. In connection with the motor a starting switch, with automatic release, was shown. The lecturer hoped the time would come when all insurance companies would adopt one set of wiring rules, which might be drawn up by the Institution of Electrical Engineers.

MULTIPHASE INDUCTION MOTORS.

By A. C. Eborall, A.I.E.E.

(*Concluded from page* 583.)

The foregoing set of curves shows clearly that practically the difference between the performance of two and three-phase motors is very small, a somewhat surprising result, as, considering the question from a theoretical point of view, the three-phase motor should prove considerably better than the motor worked with two phases under commercial conditions. In an earlier part of the paper it was shown that the variations in the field produced by three-phase currents are much less than those that would be produced in a two-phase motor, if the theoretical conditions for uniform rotation are departed from to the same extent in each case, and hence a far greater difference would be expected in the performance of the two types than is actually the case. The cause that tends to bring up the two-phase motor to the level of the motor worked on three or more phases is very simple. It is simply the effect which the reaction of the rotor has on the stator—the lines of force of the rotating field produced by the stator windings naturally spread out from the poles, and the effect of these spreading lines, taken in conjunction with the rotor currents, is to smooth down all fluctuations and irregularities in the magnetism of the rotary field, from whatever cause arising. In any induction motor this effect occurs, its extent depending on the number of phases, and as a consequence the performance of induction motors of given design depends very little on whether the motor is operated by two, three or more currents. The power factor of the two-phase motor will, however, be a little less than that of the others, and its starting powers not quite so good, the difference in this latter being of the same order as that met with in the starting of two and three-crank engines under load, where there is a slight advantage in favour of the latter.

The relative merits of two and three-phase motors are well brought out in the table on next page, for which the author is indebted to Messrs. Brown, Boveri & Co. It gives some interesting information concerning some of their standard types of motors, arranged for running on low tension circuits of 40—50 ~.

It will be seen that the weights are considerably less than those of average continuous current motors of corresponding size, even in the case of the quite small motors. In those cases where the motors are arranged for a starting apparatus, the weight of the latter is included.

The small motors (up to No. 6 inclusive) can be switched directly on the mains, and will start on full load, the momentary rush of current being two or three times as great as the full load current. Nos. 7 and 8 start with a current about equal to the full load current, the starting arrangement either being an auto-transformer (in which case they must start on a loose pulley) or a starting resistance, which enables them to start on full load.

All the other motors have wound rotors, arranged for the insertion of a starting resistance. They will start on full load not taking more than the full load current.

The current taken by all these motors running light is about 20 per cent. of the full load current.

It will be seen from the table that both weight and efficiency are the same for both kinds of motors, the difference, and that very small, being in the power factor. This is shown in the last column, which gives the apparent watts per H.P. taken at full load by the different sizes.

It should be borne in mind that hitherto nearly all the multiphase plants that have been installed have been in localities where water has been utilised as the driving power. As a consequence the question of first cost has played a much more important part than that of obtaining high power factors and efficiencies. There is no doubt that these could be commercially made even better than they are should it prove advisable.

The effect of frequency on the performance of multiphase motors is hardly felt between 30 and 60 ~ in a given design. Theoretically it should make no difference at all, and would not do so, except for the fact of the motor poles increasing directly with the frequency for a given speed. That is, in large motors, the poles become very numerous as the frequency is increased, because the speed of such motors must not be too high. The effect of increasing the poles in any given type of machine is to increase the magnetising current, and also the leakage. It is this last factor that counts the most, and so it would be expected that in high frequency motors the starting and power factor would be distinctly inferior to that of those working at the same speed, but on lower frequencies. Otherwise, high frequency motors should be cheaper than those designed for lower frequencies, as with transformers.

The whole question of the design of induction motors really resolves itself into this question of leakage, which takes into account nearly all the quantities involved, such as dimensions of air gap, induction density in it and in the stator, depth of winding in stator, and distribution and form of winding in rotor and stator. The induction motor with least leakage will always start best, have highest power factor, and be better all round.

Before concluding this paper, the author would like to make a few remarks on some special applications of multiphase induction motors to industrial purposes.

On account of its strong and simple construction, and absence of delicate parts, the induction motor is particularly suitable for workshop driving. With its low centre of gravity and compact design, it can be used in any position, with horizontal or vertical shaft, or upside down bolted to a girder, or as a side bracket—in fact, in any position whatever. It will run for months without attention, beyond

an occasional blow-out, even in the dirtiest places, such as a foundry or smith's shop; the absence of rubbing contacts, or where these are used, their simplicity, combined with the iron-clad windings and ring lubrication makes this quite possible—a result unattainable in any other kind of motor.

But it is in crane and hoist work that multiphase motors show their superiority most. Motors for such purposes have no rubbing contacts, and are wound to give a starting torque equal to four or five times the running torque, and will carry very great overloads without damage or pulling up. They can be started, stopped, or reversed almost instantly, and for ease of manipulation and control have no rival.

Reference number	1	2	3	4	5	6	7	8	9	10	11	12	13
Horse-power	¼	½	1	2	5	10	15	20	35	50	80	100	120
Approximate weight (cwt.)	0·4	0·6	0·8	1·4	4	6	10	12	21	30	43	49	59
Efficiency per cent.	60	66	73	77	83	86	88	89	90	91	92	92	92
Apparent watts per horse-power { Two-phase	1,860	1,500	1,360	1,260	1,170	1,100	1,050	1,010	1,000	990	990	980	980
Apparent watts per horse-power { Three-phase	1,800	1,460	1,330	1,230	1,140	1,070	1,040	1,000	990	980	980	970	970

The best way of using induction motors in factories is to have a separate motor for each line of shafting; the motor may have a wound rotor with starting resistance, in which case it will start against load, or, as it will in general not be more than 30—40 H.P., may have a simple short-circuited rotor and start with an auto-transformer on a loose pulley or other equivalent device. It should be so designed that its maximum power factor and efficiency occur at about ¾ load.

For all isolated apparatus of any kind, and for the large and heavy tools, or tools that require to be driven at a high rate of speed, separate motors directly coupled should be used, as the power is more under control.

For large overhead travelling cranes, three motors of different sizes are preferable to one large motor for all the movements.

Messrs. Brown, Boveri & Co., of Baden, have lately been extending the use of multiphase motors for factory driving in a new direction, namely, for driving the looms used in the manufacture of silk. These looms require from ⅛ to ½ H.P., depending on the size and type of the loom, and, to a certain extent, on the quality of the silk. The usual way is to drive the looms by belt from long lines of countershafting, and as in a very large establishment the looms are numbered by hundreds, it is clear that a lot of energy must go to the belts. Any system of direct coupling should therefore possess great advantages on the score of economy.

In several new factories in Switzerland and Italy, the above firm has supplied multiphase motors for the driving of these looms. The motors, of about ¼ H.P., are coupled to the main driving spindle of the loom by means of spur gearing, the motor either being mounted on a strong spring attached to the top of an iron pillar, and the play in all directions being taken up by the spring, or else hung up on the loom from a bracket bearing. Fig. 30 shows a part of a factory equipped with motors arranged on the latter plan, and clearly shows the manner of driving. The installation in question is really an extension of a previously existing silk factory in the neighbourhood of Zürich, and consists of about 100 looms. The three-phase motors are all fitted with squirrel cage rotors, and work at 100 volts, and a speed (unloaded) of 1,000 revolutions at 33 cycles. They were rated at ¼ H.P., but the brake tests showed that ½ H.P. could be obtained from them without a very serious drop in speed. The motors are geared to the loom by spur gearing as shown, being started and stopped by means of the same lever that controls the loom, and which is visible in the foreground of the photograph. The author can speak in the highest terms of these little motors, the ease with which they start or reverse a loom many times their size being surprising.

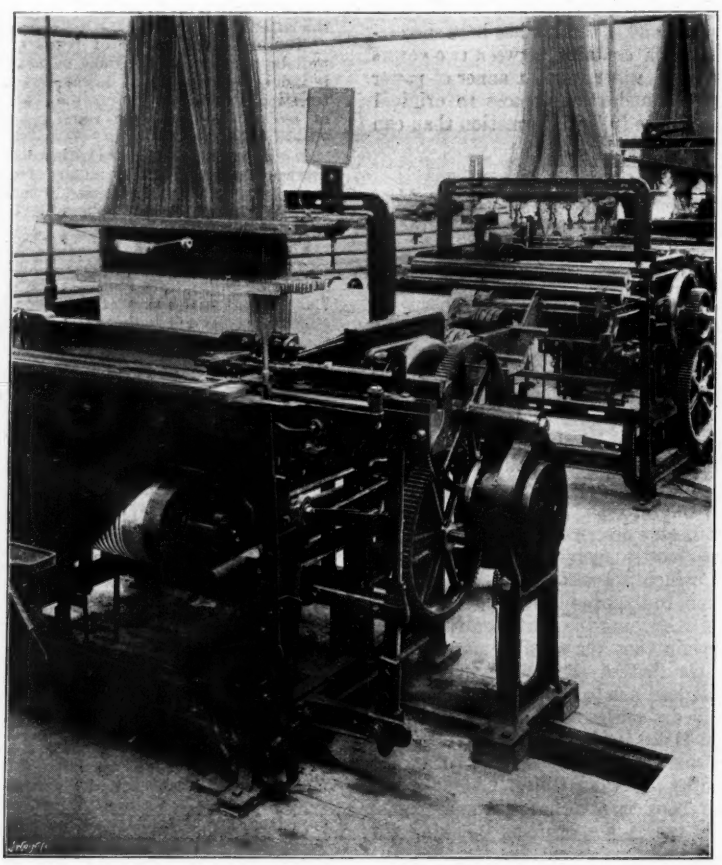


Fig. 30.

Owing to the fact that there is always some manipulation of the looms going on, the generator can be made smaller than the total capacity of the looms. Thus in this installation (if the author remembers correctly) the three-phase generator supplying power was of 16 H.P.

It is evident that the employment of induction motors for this sort of work opens up quite a new field, and should come in largely in future. It ought to possess a special interest in England, in view of the large amount of work done in weaving and spinning of all kinds, involving the use of a great number of isolated machines.

Another special application of multiphase motors is for traction work. The description of the Lugano tramway, carried out by Messrs. Brown with three-phase plant throughout, has been already described in the technical press, and the whole question is well worthy of careful study. The necessity for two trolley wires might be thought to be a disadvantage on account of the extra cost incurred in the erection of the line, and also owing to the complication of the crossings. But these objections disappear in practice to a large extent, because each trolley line has only to be about half the weight of the direct current line for the same power, and hence the poles need be but very little heavier, and in regard to the crossings, these need be no more complicated than in the direct current case, on account of the fact that if one phase of a multiphase motor is cut out, it will still continue running as a single phase motor (though, of course, with a greater drop of speed for a given load), and hence the arrangements at the crossings of a three-phase tramway would differ very little from the usual single trolley system, the motor, if properly designed, being quite able to take the load for the short periods required, although working single phase. The only disadvantage is the singing set up in neighbouring telephone and telegraph wires if these latter are parallel and near, but this is also common to direct current systems, and the remedy is to put all such wires underground, or else remove them altogether from the streets down which the tram service runs, and this is what is usually done already, aerial lines being very rarely met with in the main streets of large towns.

On the other hand, the employment of multiphase systems offers many advantages. There is the great advantage of having a motor of very strong construction, with the weak part of the direct current motor removed, and yet whose efficiency is the same or better, and whose speed regulation is just as easy (see Curves 23 and 24), while at the same time it is lighter and more compact. Further, all electrolytic troubles are done away with, and the power station can be any distance away from the line, thus allowing full benefit to be derived from cheap power or land, &c., and the line can be fed more economically than with a direct current, using step-down transformers for the purpose. Lastly, if the tram or railway be of large extent (and this is now-a-days the usual thing), the most economical system to use for a given amount of power is the three-phase system.

Another field for the employment of induction motors, and which is, as far as the author knows, quite untouched, would seem to be on board liners, and more particularly war ships. For driving pumps, fans, ice machines, elevators, hoisting shot, training guns, and many other purposes where isolated power is required on board, induction motors would seem to be particularly suitable, whether two or three-phase. The lighting could probably be done best from continuous current machines, on account of the presence of the search lights, they furnishing exciting current at the same time to the multiphase generators. But assuming the alternate current arc with properly arranged reflectors to be equal to the one produced from direct currents, there is no reason why the lighting should not be done directly from the multiphase generators. Three-phase currents would probably be best, on account of the motor leads. In this case the lamps could be arranged in three approximately equal circuits, and arranged either to take the whole voltage of the machine, or (if the generators were star connected) be placed between the neutral point and the three terminals, the neutral point being earthed. This latter arrangement has the advantage that the variation in the lamp pressure would not be so much, and the wiring of the lamp circuits would be simpler and more economical.

A great deal of misconception appears to exist as to the regulation of three-phase machines. In reality, if ordinary care is taken to distribute the load properly, it is no more difficult than with direct current machines and a three-wire system, always assuming the generator to be properly designed for its work. The reason is that in a three-phase machine whose load consists of motors, or lights and motors, the reactions of the motors tend to keep the pressures on the three leads the same. For instance, if the E.M.F. of one circuit should from any cause decrease, owing, say, to a large lamp load being switched on that circuit, the currents in the particular branches of motor windings attached to this circuit will automatically decrease also, tending to make the E.M.Fs. on the three circuits equal. To make up for the diminished current in this phase, that in the other two increases, producing a greater drop, and therefore the whole set of reactions tend to equalise the pressure on the three circuits, and lower it uniformly in amount, so that the generator fields need only be regulated in the power station to bring the line pressure up to its original amount.

The reason for the motors acting in this way is because directly the pressure on one motor circuit decreases, the back E.M.F. in this circuit increases at once, and therefore less current, or even no current is taken through it. Of course, if the three circuits are very unequally loaded, the reactions of the motors will not be sufficient to balance the system; but this self-regulation may occur to quite a large extent in properly designed plant, where the generators have small armature reaction, and are amply large enough for the work.

It is important that it should not go too far, firstly, because it produces different phase differences in the circuit, which is objectionable, and secondly, if a motor is not taking its fair share of current from one phase of the generator, or pumping back current into the generator, it will naturally be unable to stand an overload, or even its full load.

But for the slight differences of load which would commonly be met with in practice, a three-phase system of power, or light and power, can be regulated with great ease and certainty.

In conclusion, the author would like to point out that the rapidly increasing use of electrical power in gold mining and production in the colonies at the present time offers a wide field for the application of multiphase induction motors. In mining centres, where skilled labour is at a premium, the best motor is the one that is least likely to get out of order, and hence want least attention and repair; and if only on this account alone, the multiphase motor should commend itself to English engineers.

PROCEEDINGS OF SOCIETIES.

Institution of Electrical Engineers.

Some Recent Developments in Electric Traction Appliances. By A. K. Baylor. Read April 8th, 1897.

(*Concluded from page* 584.)

In making cast welded joints the rail ends are first cleaned, and then a mould is clamped around them and filled with molten iron, which forms, when it has set, a strong mechanical bond which has been found in service to withstand admirably great extremes in temperature without fracture. It often occurs, however, that the casting makes no union with the rail, and when this is the case it has little value as an electrical connection. When the joints are made with the rails at a comparatively low temperature (as they usually are, in order to secure the greatest possible contraction before joining, and, therefore, less liability of breakage in cold weather), the iron poured into the mould is apt to be chilled against the surface of the rail, preventing adhesion. Furthermore, the rail may expand slightly under the heat, contracting again when the mass has set, leaving the casting practically a shell around the joint, although supporting it rigidly. Mechanically, this may be considered an advantage, as it allows slight contraction and expansion with changes of temperature without undue strain; and in some cases the rails are painted with a compound before the iron is poured around the joint, for the purpose of preventing any union of the metals. When the rail ends are left perfectly clean it frequently happens that a good union is effected, especially at the base of the rail, where the casting is thickest, and in such cases the joint has a very low electrical resistance. Until the process can be made to ensure adhesion of the metals, however, cast joints should, as a rule, be supplemented by the usual bond connections. When this is done no saving is effected in the first cost of bonding, but the solid joint will materially decrease the expense of maintaining the connections, doing away, as it does, with vibration and movement at the rail ends. When cast joints are used, frequent cross-bonding may be sufficient guard against bad electrical contact, if the ground return is not worked to its utmost capacity, and in such cases the cost of bonding is reduced.

There are several long sections of line in America with cast welded joints that are being operated without auxiliary bonding, and with apparently perfect satisfaction and freedom from electrolysis; but it is doubtful whether some of these sections would come within the existing Board of Trade limitations in England as to drop in the ground return.

Electric welding of the joints, on the other hand, secures perfect electric continuity, and reduces the joint resistance to that of any other part of the rail. It has been found difficult, however, in practice to secure the requisite mechanical strength by this means.

Electric rail welding was formerly accomplished by placing two U-shaped yokes against the rail, one on each side, forming a link around the joint, and the weld proper was made between the ends of these yokes and the webs, 3 or 4 inches back from the rail ends. It was found with this process, although perfect union was made with the web, that the weld in cooling introduced very severe strains on the surrounding metal, and frequently after short service the links broke loose, taking out a disc of each web still in perfect union with the yokes. The process was consequently abandoned, and rails are now welded by abutting the ends together and welding them under pressure. This gives greater mechanical strength, which is the principal consideration, and as such a joint has the full conductivity of the rail, no auxiliary bonding is necessary. If these welds prove in practice to be as mechanically strong as cast joints, they will of course be preferable for electric traction, but if not, casting will be more economical, although electrically imperfect.

There seems to be no doubt that the principle of a continuous rail is mechanically sound, and that when joints are made with the rails at a lower average temperature, they are fully capable of withstanding strains of service and temperature, especially in climates with moderate extremes of heat and cold.

Three-Wire System.

In dealing with long lines extending beyond the economical limits of 500-volt direct current transmission, the three-wire system has been proposed, and applied to a limited extent in practice. This plan cannot be recommended in laying out a new plant for high tension distribution, and is by no means as flexible as alternating current transmission through sub-stations either with static transformers or rotary converters; but it may be considered in connection with existing systems that have outgrown their original capacity, and where it is desirable to increase the service with the existing plant without heavy expense for line copper and danger of exceeding a safe drop in the ground return.

Theoretically, for a given amount of copper, the potential being double, only one-half the current should be required in operating a given number of cars, if a perfect balance was maintained, the load being equal on each branch. By thus doubling the potential, and halving the current, the total line loss, with a given amount of copper, should be one-fourth that of the two-wire system. If such a balance could be maintained, reducing the track current to practically zero, danger of electrolytic trouble would be entirely removed. As a perfect balance is practically out of the question, however, the track must carry current and be bonded as with the ordinary two-wire system, and the net average saving in copper can only be taken as about 60 per cent. Various arrangements have been adopted for balancing the load. On an ordinary double-track line, with a fairly equal distribution of cars, it is only necessary to make one trolley wire positive and the other negative. The track in all cases, with this system being neutral, those cars going in one direction balance with those going in the other, and the cross-bonding between the rails represents practically the only line drop outside of the trolley wires. With a single line an equal division is not so easily made. The positive and negative trolley wires may be erected side by side over the track, the cars going in one direction using one trolley wire, and those returning using the other; but it is not desirable to bring the two wires, between which there is a difference of potential of 1,000 volts, very near together, on account of danger of leakage and risk to linemen. Another arrangement is to divide the trolley into longitudinal sections, making such sections alternately positive and negative. This gives a better division for balancing the load than where two trolley wires are used on a single track, as in case of a blockade the cars congested at a point are apt to be going in the same direction, and would therefore, on the double trolley wire arrangement, be on one side of the system, unless the trolleys on some of the cars were temporarily changed from one wire to the other. On double-track systems having branching single lines, the balance may be made by dividing the branches equally as to load between the positive and negative mains; but this has the objection of requiring the current to flow over a considerable length of track, with attendant danger of electrolysis.

Another means of dividing the load is to have every car balance itself, by running two trolley wires over each track, and mounting two trolley poles on the car, with two separate circuits between the trolley and the ground. This arrangement, however, is only to be

considered with a four-motor equipment, as otherwise series-parallel controllers could not be used. A four-motor equipment may be divided into two circuits of two motors each, handled by the series-parallel method like two independent equipments; the controllers consisting of two separate cylinders in one casing, geared together so as to act in unison. If this plan of balancing were followed with a double-motor equipment, each motor would have to be controlled separately by a rheostat—an inefficient arrangement as compared with series, parallel control.

A specially arranged switchboard for the three-wire system is shown, with the feeder switches arranged so that they may be thrown from one side to the other as desired, for balancing purposes.

In using this system it is of course necessary to divide the station into units of two generators each. If, however, it is desirable on light loads to run only one machine, all the feeders may be thrown on one side, and the line run as an ordinary 500-volt two-wire system. As the number of cars running at such times would of necessity be small, there would be no serious line loss.

Motors.

The improvements in street car motors have been along lines parallel to those followed in the development of generators. The adoption of steel has made possible the construction of much lighter, much stronger, and much more compact motors. The two-pole types have become practically obsolete, and multipolars have taken their place. The open frames necessary when machines are built of forged pieces have given way to entirely closed frames, which go far towards increasing the life of the motor and reducing expense of maintenance. Formerly the interior of the motor was open to the attacks of dust and grit in dry weather, and mud and water in wet weather, which caused rapid wearing away of the commutator and brushes and serious deterioration of the insulation. With the modern construction the armature, commutator, and brushes are completely enclosed between two bowl-shaped castings, excluding all grit and moisture. In the older forms the gearing was also exposed, and naturally cut away rapidly in service. All gearing is now enclosed in oil-tight casing, which increases its life and adds to the efficiency of the machine. The modern steel motor is, for a given output, only about one-half as heavy as the old wrought-iron bipolar type. This is clearly of the greatest importance as affecting the total weight of the car, reducing wear and tear on the permanent way, and economising power.

The principle of armature construction already spoken of in connection with generators is now followed in all the best modern street car motors. Here it is of even greater importance than in the generator, as the motor armature is much more subject to overloads and consequent danger of burn-outs.

The use of alternating current motors for traction work has made little headway. With the exception of the line at Lugano, Italy, practically nothing has been done in practice with such apparatus. In spite of the many apparent advantages of such a system, it does not adapt itself economically to traction work. When current has to be widely distributed, the use of three-phase motors will, of course, do away with the necessity of sub-stations, which is an advantage, and the absence of commutators is a large factor of economy. It is also a great convenience to be able at any given point on the line, where the conditions are severe, to place a special transformer delivering more than the normal voltage to the line, thus increasing the maximum torque of the motors for the time; or a special booster may be placed on the car and thrown into circuit whenever an increased torque is desirable. On the other hand, as the torque of this type of motor at a given voltage is limited, it is at a disadvantage for ordinary traction purposes as compared with a direct current machine, having an indefinite maximum torque under similar conditions.

It is evident that for a given surface a multiphase motor must be larger than a direct current motor. When direct currents are used, the motor may be designed for more nearly the average work; and when severe conditions are met with, as in mounting a gradient, or rounding a curve, the motor will exert sufficient torque to overcome the difficulty. A triphase equipment designed for the average work would be stalled under similar conditions. Consequently three-phase traction motors must be designed for the maximum effort which they may have to exert. Another serious drawback in the triphase equipment, as compared with direct current apparatus, is the fact that series parallel control cannot be economically employed. The use of two trolley poles is also a disadvantage, although not necessarily a serious one. Experience so far has gone to show that the use of three-phase motors for traction work must be confined to special conditions, and that for ordinary service direct current motors are much better adapted.

Controllers.

The series-parallel method of control is now used exclusively in standard practice wherever the car equipment consists of two motors. The economical advantages of this method of control are, of course, obvious, and some of the very earliest experimental equipments embodied controllers of this type. At that time it was customary to use an independent switch for passing from series to parallel, on account of the severe arcing that would otherwise occur at the instant of change. This arrangement was so inconvenient in practice, that the idea was abandoned, and for some years the motors were controlled by commutation of the fields, or by the use of graduated resistance. Now, however, that the old arcing difficulties have been overcome, series-parallel control has supplanted all other methods for double-motor equipments.

The superimposed curves shown in fig. 7 represent the comparative power consumption in starting a double-motor equipment with rheostatic and series-parallel controllers.

It follows that the more congested the service, and the more frequently the car is stopped and started, the greater is the economy to be gained by the use of series-parallel controllers, and high speed lines, or lines upon which fewest stops are made, gain least in total power consumption by their use. As the maximum possible draft, however (that is, should every car start at the same instant), on the power house of any system using series-parallel control is approximately half as much as with rheostatic control, the maximum load is brought down nearer to the average load, with a corresponding saving in the necessary generators and engine power to be provided.

When modern series-parallel controllers were first produced, many large American systems found it to their advantage to instal them on all their cars in service, and to throw away all other types of controller, the expense of the change being many times offset by the increased service of cars possible without additional power-house capacity or line feeders. If on a system using this method of control one-half the station capacity should be disabled, all the cars could still be

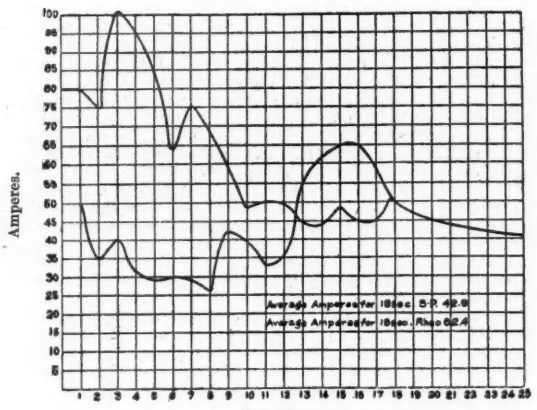


Fig. 7.

operated by being run in series, and therefore at half speed, which would inconvenience the public much less than taking half the cars out of service and running the remainder at full speed. This plan also has the commercial advantage that just as many passengers can be carried, although the car mileage for the time being is reduced.

The mechanical features of the modern controller have been carefully developed, and every precaution has been taken to prevent careless or unskilful motor men from injuring the apparatus. It is usual to so interlock the power and reversing cylinders by means of gearing that it is impossible to move the power handle unless the reversing switch is fully thrown either forward or backward, and impossible to move the reversing switch unless all power is cut off from the motors.

Electric Brakes.

In dealing with modern mechanical traction, the question of proper brake facilities is of the utmost importance. As compared with the ordinary horse car, a mechanically propelled car is necessarily heavy. A large factor in this increased weight is the heavy truck frame necessary, and to this is added the weight of the driving equipment. Moreover, the size of car bodies has been increased, and their weight is proportionately greater, due to the heavy framing which is required throughout, in order to withstand the strains incident to mechanical traction service. The difficulty of braking such cars is increased in direct proportion to the increased weight, and in addition to this the average speed of an electric car is nearly, if not quite, twice that possible in ordinary horse service, which is a more serious consideration than the weight, as the difficulty of braking increases with the square of the speed. Under these conditions the best possible arrangements of hand brakes and levers impose an undue burden upon the motor man, and call for an amount of brute force inconsistent with perfect handling of the vehicle. The application, therefore, of power brakes to street cars is worthy of very serious consideration, as they enable the motor man to stop his car under all conditions without muscular exertion, leaving him free and on the alert for any emergency.

As the most recent developments in electric car equipments are in this direction, I am here considering them at some length.

Air brakes on street cars have been fairly successful in so far as they permit of the application of powerful braking effect without taxing the driver; but upon electric cars, where the generating power of the motors may be availed of for braking, air brakes have little to recommend them. In the usual form of air brakes used in street cars, the air pressure is derived from eccentrics driven from the axle, so that pressure can only be generated while the car is running. It is undesirable to use a separate motor for operating the pump in ordinary practice, on account of cost, inefficiency, and the limited space available for additional apparatus outside of the necessary driving motors and other accessory equipment. It is difficult even to find room for air receivers on the average street car. When the pump is driven from the axle the receiver must of necessity be of ample dimensions, as repeated applications of the brake may follow one another at short intervals of space, the pressure absorbed in each application exceeding that generated between stoppages. A continuance of this process may so reduce the pressure that it will be inadequate for controlling the car in case of emergency. With a properly constructed electric brake, on the other hand, the frequency of

stoppages is immaterial, as it is the current from the motors, driven by the motion of the car itself, which furnishes the braking force. Moreover, the efficiency of mechanical friction brakes is greater at low speeds, and falls off rapidly as the speed increases; the electric brake, on the contrary, is most effective at high speeds, as the faster the motor armatures are revolving the more promptly will current be generated.

The idea of converting traction motors into generators, and utilising the current for braking purposes, is an old one, and has been applied in practice to a limited extent for many years. Hitherto electric braking has been little used, although any ordinary motor equipment embodies a practical emergency brake which may be applied by short-circuiting the motors either directly or through resistance. This practice imposes such severe strains, both upon the windings and gearing, that it can only be used as an emergency measure, and is quite out of the question for regular braking. In order to apply this emergency brake when there are two motors on the car, it is only necessary to put them in parallel and throw the reversing switch as if to go backwards. The generated voltages will then oppose each other, and the weaker one will be overcome, resulting in a counter current, through the corresponding motor reversing its field. The motors now being in series instead of in parallel, with nothing but the motor windings in circuit, a powerful current is generated, which increases until the momentum of the car has been checked. It is, of course, clear that whenever a traction motor to be thus used as a generator, it must be reversed, otherwise the first effect of generation would be to oppose the residual field and reduce it to zero. It sometimes happens that the voltages of two motors in parallel so nearly balance each other, that the difference in potential is insufficient to quickly build up the fields, and this insufficiency may be aggravated by resistance at the brushes or some other part of the circuit. Under such conditions the car would run some distance before the generation of a current strong enough to act as a brake. To avoid this possibility, "emergency switch" connections are now so made that the motors are independently short-circuited, and the full potential of each motor is brought at once into play. The effect of thus turning the motors into generators is practically instantaneous, and the electrical and mechanical strains are excessive. It is clear that the magnetic drag upon the armatures, due to their generator action, furnishes the entire retarding force, and the braking effect is delivered to the wheels through the gearing. Gear wheels or pinions have been repeatedly stripped or broken in this way, and frequent use of this method of stopping is a serious tax upon the insulation of the motor windings. However, to avoid collision or running down a pedestrian, such a switch is effective, and therefore valuable, and at such times the breaking of a gear or the burning out of a motor is not to be considered. The strain upon the motor may be reduced by introducing resistance in circuit; but if this resistance is sufficient to afford full protection to the motors, it will be impossible to stop quickly, and therefore the value of the arrangement as an emergency brake is destroyed.

The latest form of electric brake is based upon an entirely different principle of action, and permits of the car being controlled at all times by the motors in stopping as well as running. The arrangement consists of a circular iron plate made fast to the axle, and turning with it, and an electro-magnet also, in the form of a disc, which is mounted so that it cannot revolve. The magnet disc is usually mounted upon the motor frame. In one form one of the axle bearing caps is cast with projecting lugs to support it. With this form of brake all forces tending to urge the car ahead are opposed directly and simultaneously, reducing internal strains to a minimum, and bringing the vehicle to rest in the least possible time. The current from the motors is thrown by graduated steps through the magnet discs, bringing them into

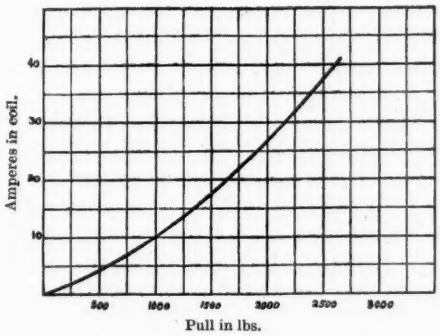


Fig. 8.

close contact with the axle discs, the resulting friction retarding the latter, and with them the car wheels, while at the same time the generator action going on in the motors tends to bring the armatures to rest, thus increasing the braking effect, and relieving the gearing from strain.

In addition to these forces there is another retarding action, due to the eddy currents set up in the axle plate as it revolves in the field of force surrounding the magnet. From the curves shown in figs. 8 and 9, it will be seen that this Foucault current effect is an item of considerable importance in the efficiency of the brake. Fig. 8 shows the static pull, in pounds, on the magnet disc with a given excitation in the coils, with the car at a standstill. In fig. 9 the curves represent running tests. The upper set of lines show the actual coefficient of retarding effect for different currents in the brake circuit, and the lower set of lines represent the coefficient of retarding effect for corresponding mechanical pressures, all readings being taken as nearly as possible, under similar conditions. It will be seen from these curves that the actual efficiency of the electric brake at a given current is about twice what it would be if acted upon by a direct mechanical pressure corresponding to the static pull with such a current. This additional retarding effect is due to eddy currents and magnetic strains set up in the shoe and disc, and is, of course, secured without wear on the parts.

To prevent excessive wearing, hard metals must be used for the discs, and some difficulty was at first encountered through residual magnetism, and the tendency of the discs to cling together after the car had come to rest, requiring an excess of power in starting again. It is, of course, impracticable to use soft iron, as the wear on the friction surfaces would be excessive; but the difficulty has now been

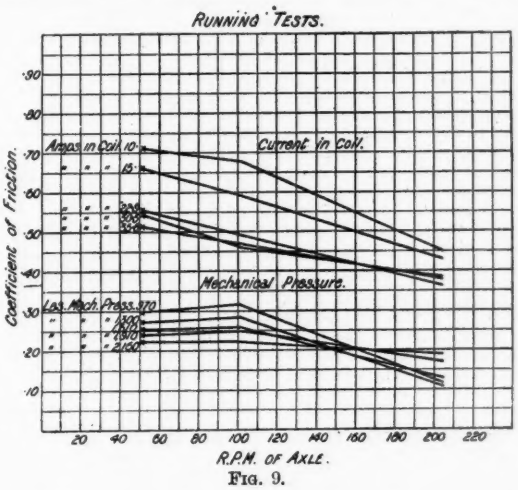


Fig. 9.

obviated by connecting the brake circuit, through a resistance, in shunt with the first running position of the controller, by which means a weak current is sent through the brake magnets as soon as the handle is moved to start the car. The shunted current flows in the reverse direction to that delivered to the magnets by the motors, and overcomes any residual field that may be present in the discs.

Formerly, in dealing with trail cars, with this form of brake a separate magnet disc was placed on the rear axle of the motor car in the form of a drum, upon which was wound up a chain actuating a mechanical brake on the trail car. This plan is obviously imperfect, as there is no certainty that the brakes on the rear car will retard the wheels in unison with the electric brakes on the motor car. The present practice, therefore, is to mount upon the axles of the trailer magnetic and axle discs similar in every respect to those on the motor car, excepting that the rotation of the magnet is prevented by a connection to the truck frame, there being no motor to support it. The trail car magnets are connected in series with those on the motor car, thus ensuring an absolutely uniform braking effect on every disc.

As a factor of safety, the train, as in railway practice, should be under full control of the man in front, who has a clear view before him, and who must in all cases of emergency rely upon himself only to avoid accident. With a proper system of signalling, an independent brakesman on the trailer, if skilful, may under normal conditions stop his car in approximate unison with the motor; but he is of absolutely no assistance to the motor man in cases of sudden emergency, and the added inertia of his car at such times reduces the efficiency of the brakes upon the motor. As a factor of economy in power consumption also the motor man should control the train, as much current is wasted through too early application of the trailer brakes imposing a drag upon the motor.

An electric brake has an advantage over any simple friction device when the car must be stopped within a minimum distance. It is well known that a better braking effect can be attained by retarding the wheels up to a limit just below the slipping point, than by passing this point and skidding the wheels; and not only does skidding prevent effective braking, but it usually means flattened wheels—a result both troublesome and expensive. Under the most favourable conditions it requires skill and precaution with ordinary friction brakes, whether operated by air or by hand, to bring a car to rest without skidding the wheels, and in emergency the first impulse of the motor man is to set his brakes hard, which will, as a rule, cause skidding. Thus at a time when a quick stop is most necessary, there is least liability of its being effected with mechanical friction brakes. With an electric brake this tendency to skid the wheels is prevented automatically, for the armature is connected through the gears and axles to the wheels, and the latter cannot stop turning without also stopping the armature, and with it the current from which brake action is derived. When the wheels begin to turn again they are again retarded until the car has been brought to rest.

It should be noted that this action is essentially automatic, and requires no skill and experience on the part of the motor man, being, in fact, quite beyond his control; therefore with such a braking device greater speeds are possible with a given degree of safety, and the personal factor of the motor man in this particular is practically eliminated.

It has been found in practice that even with an electric brake a

slight flat wheel might occur if the full current from the motor were free to flow through the magnet discs. This is due to the fact that the first surge of current would stop the wheels, and although they would begin to turn again, an appreciable time would be required to overcome the inertia of the armatures and the sticking of the discs, and during this interval there would be danger of skidding. Moreover, the first flow of current from the motors under these conditions is far in excess of that necessary to stop the wheels, and the surplus only heats the motors, imposing a strain on the insulation of the windings, while doing no useful work. To overcome this difficulty, an arrangement known as the "limit switch" has been provided, which consists of a small coil of wire in series with the brake discs. When energised, this coil lifts an armature, making connections which cut out the fields of both motors, thereby stopping the current. The armature of the limit switch is controlled by an adjustable tension spring, which is set to allow for the current being cut off at a point which prevents the wheels from actually stopping. This limit varies with different weights of car and different conditions of track; but with the ordinary electric car and average track conditions, it is between 30 and 35 amperes, and when this is divided between two motors, there is, of course, no danger of heating the conductors or destroying the insulation.

It should be noted that but for the residual magnetism left in the discs, and their consequent tendency to stick together until demagnetised by the line current, an electric brake would not hold a car absolutely still on a gradient. It is evident that, when the car has been stopped and the current from the motors ceases, the wheels, but for this sticking, would begin to turn again, as already described. As a matter of fact, on heavy grades this sticking is insufficient to hold the car, and unless the auxiliary hand brakes are applied the car will start again by gravity. As soon as it does this, however, the generating action begins again in the motors, and the effect in practice is that the car will move down the grade at a snail's pace, the current from the motors all but balancing its tendency to move.

The electric brake connections in the controller are usually placed upon the reverse side of the power cylinder, only one handle being used, which is turned one way to supply power and the other way to apply the brake, the same resistance with different connections serving with both circuits. It is possible to continue the shaft of the controller down through the platform, connecting it with the ordinary brake rigging and peripheral brake shoes (which should always be placed upon the car as an auxiliary). When arranged in this way the controller handle, after passing through the various braking steps, may be turned farther, setting the brake shoes, which will require but little pressure, the car being practically at a standstill. This seems inadvisable, however, as the brake shoes would in all probability be applied at every stop, and unnecessary binding of the wheels and possible flattening would ensue. It may be noted, however, that with an electric brake one flat spot on a wheel has no tendency to produce another, as is the case with peripheral friction brakes that tend to grip the wheel where flattened, causing skidding that would not normally occur.

The saving by the use of electric brakes in wear and tear on wheels and replacement of brake shoes is a considerable item of economy in ordinary service. The wear on wheels due to the grinding action of peripheral brake shoes where frequent stoppages are necessary amounts to more than that due to rolling friction on the tracks, and the brake shoe has to bear its share of the effects of this grinding action.

A source of considerable waste in power consumption on individual cars with ordinary equipment is the tendency of motor men to put on brakes before power is completely cut off, and to throw on power before the brakes are fully released. With an electric brake operating from the reverse side of the controller cylinder this is impossible, as the handle must pass through zero, or "off" position, in going from power to brake, and in going from brake to power.

Various forms of so-called electric brakes have been devised whereby the ordinary rigging and shoes are employed with some form of electro-magnet to take the place of the usual handle in applying power to the chain. Such brakes may be operated by current from the overhead line or from batteries on the car. The brake deriving its power from the line is unreliable, as the trolley may leave the wire at a critical moment, rendering the brakes inoperative, and storage batteries necessitate the addition to the car equipment of heavy and expensive apparatus. In common with air brakes, such devices are open to the criticism that in providing an auxiliary it is necessary either to duplicate the rigging and shoes—which is impracticable in the space, already overcrowded—or to rely upon a reserve source of power only, trusting to one set of shoes and connecting mechanism. With air brakes, too, they must be classed as uneconomical for electric cars, since such cars must of necessity embody in the motors an ample and flexible braking power, whether it is availed of or not, which runs to waste when any other force whatsoever is used in braking. We might as logically run our electric cars by horses, with the motors dragging upon the axles, as to use some other and less effective means of braking than that obtainable from the revolving armatures while their inertia urges the car ahead.

THE DOVER CORPORATION ELECTRIC TRAMWAYS.

A paper on this subject, by Mr. Henry E. Stilgoe, Assoc.M.Inst.C.E., borough engineer of Dover, was read before the Association of Municipal and County Engineers at the home counties meeting held at Dover on Saturday last, April 24th. We give an abstract of the paper in so far as it will be of interest to our readers.

The author was instructed to prepare plans and sections of the tramways for the 1896 session, and the provisional order then obtained was subsequently confirmed by Parliament. The Act gave the Corporation power to operate the tramways by horse or mechanical traction (except steam locomotives), and the power, which had never been granted to a local authority before, viz., that of working the tramways.

The tramways are single line with passing places; the total length being 4 miles 3 furlongs 6·05 chains, of which 3 miles 1 furlong 8·15 chains is single line, 1 mile 1 furlong 2·25 chains double line, and 5·65 chains interlacing lines. The centre line of the tramway corresponds with the centre line of the road, except for a short length, where it was necessary to go to one side to pass round a sharp corner. The gauge is 3 feet 6 inches, and was decided by the narrowness of one or two of the streets through which the line passes; but in the interest of economy of the initial cost of permanent way, the author would have recommended it in preference to a broader gauge. At the passing places, which are three chains in length, the distance between the centre of each pair of metals is 7 feet 6 inches.

The permanent way, which has been designed by the author, consists generally of steel rails of the girder type, weighing 87 lbs. per yard. The rails are 30 feet long, 6 inches deep, and are slotted for the tie bars and drilled for the fish bolts and electrical bonding, which is being carried out on the Chicago method. A portion of the head of the rail is cut away at the joint for fitting the outer fish plate. The fish plates are of steel, 20 inches long, and are of special design, made by Messrs. Dick, Kerr & Co. The outer plate is of the full height of the rail above the flange, and fits into the portion of the head of the rail cut away to receive it. The object of this high fish plate is to add strength to the rail at the joint, which is its weakest part. The fish bolts are of wrought-iron, $\frac{7}{8}$-inch diameter, four bolts being used at each joint. The tie bars are also of wrought-iron, 2 inches × $\frac{3}{8}$-inch, with a double grooved head to fit the slot in the rails; they are placed 8 feet centre to centre, and 3 feet from the ends of the rails. The points and crossings are of crucible cast-steel, except two or three special crossings, which are built from the girder rails. Marshall's patent spring points are used; they are 7 feet 6 inches long. The crossings are 4 feet long, and the angle is 1 in 5. Dawson's patent drain rails are used at various points; they are a contrivance made to drain the water from the groove in the head of the rail, and can be connected to the drains in the street. The passing places, which, as before mentioned, are 3 chains in length, are laid in the centre of the roads; the distance between the centre line of each pair of metals is 7 feet 6 inches where they run parallel. These are designed so that two or even three cars may stand on one pair of metals, while the same number of cars pass on the other. The reverse curves from the single to the double lines are 300 feet radius, and allow the car to travel with great ease, and the consequent comfort of the passengers and saving of wear and tear to the rolling stock.

Each rail is laid on a continuous block of Portland cement concrete (5 to 1) 12 inches wide and 8 inches deep. The concrete is mixed and laid with great care, and finished to a true surface; the roadway between the rails, and for a distance of 25 inches outside of each rail, is paved with Guernsey granite setts, 5 inches deep and 4 inches wide, $\frac{5}{16}$ inch above the level of the rails, grouted in with Portland cement mortar (3 to 1) well swept into the joints, and laid on a $\frac{1}{2}$-inch bed of sand on a 6-inch foundation of Portland cement concrete (7 to 1).

With regard to the motive power of the tramways, it may here be briefly stated that, acting on the report prepared by the Town Clerk of Dover, and the author, as to the duties and cost of the various modes of tramway traction, the Town Council decided to adopt the electric trolley system.

Acting on the advice of their electrical adviser, Mr. Stephen Sellon, Assoc.M.Inst C.E., who had carefully considered the question of whether it would be more advantageous for the Corporation to have its own power station or to take the necessary current from the Dover Electricity Supply Company, the Corporation entered into an agreement with that company to provide all the power required for working the tramways at a price of 3d. per Board of Trade unit, subject to reductions on a sliding scale as the consumption of energy increases.

This installation possesses features of unusual interest which deserve the careful study of all interested in the success of either tramways or electric lighting stations. The well-known disadvantage that all electric supply stations labour under, is the want of a day load, and the consequent length of time that the plant is not only not earning a dividend, but that its stand-by losses are constituting an actual drawback to the dividend earning capacity of the undertaking. Tramways, on the other hand, find the inevitable fixed charges in connection with a generation station (and particularly with those of smaller size) are a serious consideration, and make it possible for a tramway to purchase its supply of electric energy from an electric lighting station at a price which, while yielding them a fair profit, will be below the cost at which the tramway can generate its own electricity. The Dover Corporation is the first body which has practically grasped the economic possibilities of the problem before them, and the Dover Tramways will be the first tramways to be worked from an existing electric lighting station.

The power station is situated about the centre of the system. The generating plant which the Dover Electricity Supply Company will instal will consist of two 200 horse-power Babcock & Wilcox water-tube boilers, and two horizontal tandem compound engines, running at a speed of 235 revolutions per minute, and coupled direct to four-pole compound-wound railway generators, giving an output of 100 kilowatts at 500 volts.

The steam consumption of each engine will not exceed 18½ lbs. of steam at 150 lbs. pressure per indicated horse power per hour, and the over-all efficiency of each engine and generator combined, that is to say, the ratio of the energy available at the terminals of the machines

to the indicated horse-power of the engine driving it, will not be less than 84 per cent.

A motor generator of a capacity of 30 kilowatts will be provided, the alternator side to take or generate current at 2,500 volts at a frequency of 100, and the dynamo side to take or generate current at 500 volts and 60 amperes. This arrangement will provide simple and economical means of handling the cars in and about the car sheds, &c., when the main engines are shut down.

Separate switchboards of enamelled slate will be provided for each dynamo and the motor generator, together with ammeters and voltmeters, both continuous recording and otherwise, automatic circuit breakers with magnetic blow-outs, lightning arresters, and recording wattmeters for measuring the consumption of energy, and the apparatus required for complying with the requirements of the Board of Trade.

The electric equipment of the line is being carried out on the side trolley system, with two No. 0 B. and S. special copper wires extending the whole length of the route, carried 21 feet 6 inches from the ground on ornamental tubular steel poles.

The steel poles are 31 feet long; the first section is of 6-inch pipe 16 feet 6 inches long, the second section of 5-inch pipe 7 feet 3 inches long, and the third section of 4-inch pipe 7 feet 3 inches long. The base has an ornamental cast-iron sleeve, and the top is fitted with a cast-iron terminal or lamp as required. They are sunk 6 feet in the ground, and set in concrete, and are placed 40 yards apart where the line is straight. Side brackets are fixed to the poles when placed on the kerb, the lengths of the arms being adapted to the varying widths of the roads, and double brackets when the poles can be placed between the double lines; for instance, along the Market Square. Steel guard wires with insulated supports are fixed where necessary for the protection of telegraph and telephone wires.

The tramways will be divided into three sections, radiating from a central feeder pillar, and will be further divided into half-mile sections at suitable switch pillars. The use of a double trolley wire, in addition to its other advantages, obviates the use of frogs, unsightly overhead gear, and minimises sparking. Every attempt has been made to introduce an ornamental as well as a thoroughly efficient system of tramway traction. It is the intention of the Corporation to fix arc lamps of ornamental design on the upper portion of a number of the standards, notably, in the Market Place, where centre pole construction is adopted.

The cars will be capable of holding 20 passengers inside and 24 out, and will be carried on Peckham spring cantilever trucks of special design, and provided with two 25-horse-power motors, series parallel controllers, electric and mechanical brakes, &c. A special feature will be the fitting of a wattmeter on each car, so that the consumption of energy on each car can be recorded. There will be eight motor and two trailer cars.

The entire tramway and car sheds will be at intervals put into telephonic communication with the Dover Electricity Supply Company's works and the offices of the borough engineer, who will be provided in his own office with a switchboard and separate set of recording instruments, from which at a glance he will be able to check the efficient electrical working of the entire system. A car shed will be built at Buckland, and another at Maxton, from designs prepared by the author.

The cost of the works now in hand is estimated to be as follows:—

	£
Laying 3 miles 6·45 chains of single line with passing places	15,600
Electrical equipment ditto, including eight motor and two trailer cars	8,200
Two car sheds and land	3,000
Electrical bonding	900
Total	£27,700

CORROSION AND SCALE FROM FEED WATERS.

A readable article in the *Engineering Magazine*, by Mr. A. A. Cary, deals with feed waters and corrosion in steam boilers and emphasises the necessity, where zinc is used to prevent corrosion, of having thorough electrical connection of the zinc and the boiler shell. It points the warning, too, against impure zinc. Zinc may contain lead, a metal the very opposite to zinc in its relation to iron, for lead is electro-positive and the boiler wastes—not the lead. Corrosion of the grooving variety is usually caused by unequal expansions and can usually be dealt with only by good design. Corrosion by pitting may be due to gases in the water. Thus oxygen and carbonic acid are very active corrosive agents, and, though removed by boiling, show of what they are capable when introduced with cold feed. This is an argument for a hot feed that is too little advanced. Cold feed water contains gases which are peculiarly powerful as oxidisers of iron; cold feed has also a powerful effect in producing alternations of expansion and contraction. These alternations resemble in their effects the repeated to and fro bending of a sheet of metal or a wire. They produce an open surface peculiarly liable to corrosion. The effects of cold feed are therefore of double intensity by virtue of the combined influence of the molecular disturbance and the occluded gases. The effect of the alternations of temperature serve to destroy the scale that might protect the surfaces. Thus the parts most strained by the alternations are least protected and waste at an abnormal rate. "Pure water" is apt to be corrosive. Thus the old Manchester supply would boil away for months without use of the blow-out and with no resultant scale, but it had some peat acid in it and required a little alkaline treatment. All natural soft waters are apt to be corrosive. Our advice for the treatment of such waters is to add a little lime to the feed or limestone may be deposited in the reservoir or used in the form of chips as a filter through which to pass the feed water.

The economiser being of cast-iron is a useful feed heater because in it the feed may be purged of its oxygen, and cast-iron is less affected by the occluded gases than is wrought-iron or steel. The grooving due to bending and corrosion combined, pitting due to gas action, and general wasting due to acid water, are all well illustrated and lime is advocated as a means of giving a protecting coating to iron, to be fed in as milk of lime as advocated many years ago by the present writer. Inspectors are warned to beware of that peculiar general corrosion which sometimes evenly wastes plates, overlaps, and rivet heads, and may be overlooked by its very rarity. At the same time we would caution men against jumping too hurriedly to the conclusion that a boiler is weak because the plates are badly honeycombed, for it requires a lot of honeycomb and pitting to reduce the strength of a plate to that of an unwasted seam of rivets, and often the rivet seams are almost untouched where the plates are gone in the body nearly a fourth. To the layman's eye a plate that is as strong as new often presents a most delusive and terrifying aspect of weakness, and we have seen good boilers condemned by men who allowed appearances to scare them. Chloride of magnesia, a salt found in the sea, is very unstable at high temperatures, and decomposes to hydrite and acid thus:

$$Mg\,Cl_2 + 2\,(H_2\,O) = Mg\,H_2\,O_2 + 2\,(H\,Cl)$$

this last—hydrochloric acid—being obviously a dangerous corrosive, and we have known a tube go in 48 hours, owing, it is thought, to this action. Mine waters, swamp waters, and kerosene may all be very corrosive, the last because frequently acid from the treatment followed in the purification. Sulphuric acid is used and ought to be neutralised, but often traces of acid remain. Great care ought to be exercised in using kerosene. Our author properly suggests the testing two or three times weekly with litmus paper, which should be practised whenever there is reason to suspect acid is likely to be at any time present, or the more effectual test of 2 ounces of phenol-phthaleine in every boiler. So long as no acid be present, this will keep a pink tinge in the gauge glass, but will fade when acid is present. It ought to be renewed as gradually lost by blow-out or priming. To our way of thinking boiler-feed ought, if possible, to be dealt with before heat has been largely expended. For carbonate waters the Porter-Clarke process, with caustic lime, or the soda process for lime sulphate, will often prove satisfactory, and save fuel as well as plates and labour. Barium also may be used with excellent effect, for it has an advantage over soda in that its sulphate is insoluble and deposits, whereas sulphate of soda remains soluble in water, and only deposits on concentration with great risk of danger. Altogether Mr. Cary's article is interesting and suggestive.

AUSTRALASIAN ELECTRICAL NEWS.

[FROM OUR SPECIAL CORRESPONDENT AT SYDNEY.]

Considerable activity has been evinced of late in Australasia in applying to the Parliaments and municipal authorities of the various Colonies for concessions and Bills of all sorts. In New Zealand a Bill has been brought before Parliament by the Premier, making it obligatory for local authorities to obtain the consent of the Governor-in-Council to any proposed concession for the use of electricity as a motive power. From the passing of the Act any right granted for generating or using electricity for power purposes without such authority will be null and void. The effect of this retrospective clause has naturally been to cause strenuous opposition from vested interests already established.

In Tasmania, the Hobart and North Western Mineral Fields of Tasmania Railway Company has been registered, its objects being to acquire from private parties plans of survey, reports, and a draft Bill now before the Tasmanian Legislature in reference to a proposed railway from Hobart to the north-western mineral fields of Tasmania, to construct and work the said railway and extensions of the same, and to take water from Lake Augusta and other sources for the production of electricity, &c. The capital of the company is £10,000 in 100 shares of £100 each.

The Parliament of Western Australia has been asked to consider a Bill, having for its objects the generation and transmission of electrical power for mining purposes, the applicants being the Scottish Westralia Company, Limited. This company has been formed with a capital of £750,000 for the purpose of providing the gold fields with electrical energy and light, and it is stated that the proposed scheme has been approved of by Lord Kelvin. The company has already secured from the Government permission to utilise the railway track from Perth to Coolgardie for the erection of poles, &c., for the transmission conductors, the company depositing the sum of £2,500 as a proof that business is meant. The company estimates that by using a high tension overhead system it will be able to sell electrical energy on the gold fields at the rate of 5s. per horse-power per day. This rate is held to be equivalent to 5s. per ton of ore crushed, whereas the present cost of mining and milling ores varies from 30s. to 80s. per ton according to local conditions. Machinery capable of generating 20,000 electrical horse power is to be installed if the requisite permission is obtained. The Perth City Council, realising that concessions are a marketable

commodity, decided to advertise for tenders from persons desirous of applying for the right to construct and work a system of electric tramways within the municipality. Applications had to be accompanied by a preliminary deposit of £100, to be increased to £5,000 prior to permission being granted for the provisional order. Under these conditions applications have been received from the Colonial Finance Corporation and Mr. George Leake, but no decision has been come to in the matter. The above Council decided to retain the electric lighting of the city in their own hands, and have adopted a resolution to engage an expert to advise upon a scheme of lighting. The lighting of Kalgoorlie by electricity has been finally decided upon and an offer by Messrs. Sedgwick & Co., Limited, to erect and hand over in running order a complete plant, has been accepted at a price of £7,500.

In New South Wales, Goulburn and Coonamble have practically decided to adopt electric lighting. The Goulburn Council, who now pay about £1,000 per annum for street lighting, intend to provide for both street lighting and private lighting, the estimated cost of the necessary plant being put down at about £7,000. The Municipal Councils of Tamworth, Moree and Narrabri have decided to combine together to obtain a bill authorising them to supply electricity to private citizens. There is already a small plant at Tamworth used principally for street lighting, and it is expected that the proposed new water supply scheme will provide a sufficient surplus pressure for power purposes. At Narrabri the Council some months ago accepted a tender from Crompton & Co., at £2,800 for a plant for 400 16-C.P., 40 25-C.P., and 4 arc lamps, the arc lamps and 25 C.P. incandescent to be used for street lighting; the matter was then delayed for some time while the Council proceeded to raise a loan of £3,000 for carrying out the work, which has now been obtained and the work is to be commenced shortly.

The Electric Traction Act of 1896 recently assented to by the New South Wales Legislature empowers the Railway Commissioners to use any approved system of electric traction in addition to or in substitution for any mode of traction now employed, and it is noticeable that as present rails are being relaid the joints are being bonded. The extension of the Military Road Electric Tramway to Mosman's Bay has been completed and opened for running, and tenders have been let for the generators and various other minor portions of the contract for the new George Street line. The Electric Association of N.S.W. is making a determined effort to induce the Government to introduce a General Electric Lighting Bill on similar lines to the English Act, as has already been done in Victoria and Queensland. Electric lighting privileges, both public and private, are being applied under the Victorian Act by the New Australian Electric Company, Limited, the A. V. Alcock Electric Light and Motive Power Company, Limited, and the Union Electric Lighting Company. The area for which the latter company asks lighting powers is within the boundaries of the City of Melbourne, while the other companies include with the city a number of the suburbs. Similar concessions are being sought by the Ballarat Electric Supply Company, Limited, the Bendigo Electric Company, Limited, and the Nhill Electric Supply Company, Limited, in respect to those cities, all the above named being at present in existence. The Geelong Electric Supply Syndicate is applying to the Governor in Council for a provisional order under the Act to supply electricity for private and public purposes within the town of Geelong and its suburbs.

Queensland has added the latest to the list of central electric supply stations in the Australian colonies by the successful completion of the work at Charters Towers by Messrs. Crompton & Co. The system adopted is a high tension alternating current, with underground mains in the principal streets, consisting of armoured Callender cables laid direct without conduits. The boilers were made in Brisbane by Messrs. Evans, Anderson, & Phelan, supplying steam to a Browett & Lindley engine direct coupled to a 40 kilowatt Crompton alternator, which is already well loaded. At a special meeting of the Brisbane Municipal Council a resolution was adopted that specifications for an electric lighting plant suitable to the requirements of the city, and an estimate of the cost be prepared and submitted to the Council.

The Launceston Municipal Electric Lighting Station, a full description of which recently appeared in the Review, is so successful that already tenders are being called for two more complete sets of turbine, alternator, and switchboard panel. The report of the Launceston Gas Company states that the reduction of the dividend is due to the installation of the municipal electric lighting system.

Refrigerating Plant Operated Electrically.—The Quebec Storage Company have installed in Quebec city an electrical plant for operating their refrigerating machinery. For this purpose two 50 and two 15-horse-power two-phase "S.K.C." induction motors. The larger size are to replace steam engines for the operation of the compressers; one of the smaller motors will work a fan for driving air over the pipes to be cooled, and the other operates a pump for the circulation of the brine. The motors are belted direct to two lines of shafting, which, according to the *Canadian Electrical News*, are so arranged that by friction clutch they can be made one. Current is supplied from the two-phase generating plant of the Montmorency Electric Power Company, fully ten miles distant from the Storage Company's refrigerating work.

NEW PATENTS AND ABSTRACTS OF PUBLISHED SPECIFICATIONS.

NEW PATENTS.—1897.

[*Compiled expressly for this journal by* W. P. Thompson & Co., *Electrical Patent Agents*, 322, *High Holborn, London, W.C., to whom all inquiries should be addressed.*]

9,222. "Improvements in and relating to the covering and fixing of electric wires." E. Haslam. Dated April 12th.

9,276. "Improvements in primary batteries." W. Rowbotham. Dated April 12th.

9,295. "Improvements in recording telegraphic receivers." H. W. Handcock and A. H. Dykes. Dated April 12th.

9,317. "Improvements in plates for secondary batteries." Sir C. S. Forbes, Bart. Dated April 12th.

9,323. "Improvements in electric signs or illuminations." B. M. Drake and J. M. Gorham. Dated April 13th.

9,348. "Electric locks." E. J. M. Schebben. Dated April 13th.

9,350. "Improvements in electric incandescent lamps." G. T. Cannon. Dated April 13th.

9,367. "Improved means for lighting by electricity and incandescence." J. A. Sinclair. Dated April 13th.

9,425. "Improvements in electro-magnetic clutches or couplings." V. A. Fynn. Dated April 13th. (*Complete.*)

9,435. "Improvements in or in connection with constant current generation and regulation." W. P. Thompson. (T. H. Hicks, T. S. White, and T. Friant, United States.) Dated April 13th. (*Complete.*)

9,442. "Improvements in pressing electric collector brushes and the like articles." R. R. von Berks and J. Renger. Dated April 13th.

9,456. "Improvements in secondary batteries." J. H. McLean and C. D. Burnet. Dated April 13th.

9,457. "Improvements in electrical transformers." A. T. Berry. Dated April 13th.

9,477. "An improvement in magnetic compasses for military and other purposes, more particularly for use at night." T. W. Short and W. J. Mason. Dated April 14th.

9,533. "Improvements in and relating to reflectors for electric glow lamps." H. J. Mutz. Dated April 14th.

9,537. "Improvements in commutator truing devices." P. B. Bosworth. Dated April 14th. (*Complete.*)

9,561. "Improvements in the means for controlling carbon feeding mechanisms for electric lamps." W. D. Hunter. Dated April 14th.

9,563. "Improvements in or relating to plates for secondary batteries or accumulators." H. T. Cheswright. Dated April 14th. (*Complete.*)

9,564. "Improvements in apparatus for the raising and lowering of arc lamps." W. J. Davy and G. Thomas-Davies. Dated April 14th.

9,586. "Improvements in current collecting apparatus for electric tramways." C. W. G. Little and A. J. Ireland. Dated April 15th.

9,587. "Improvements in electric measuring instruments." Evershed & Vignoles, Ltd., and S. Evershed. Dated April 15th.

9,594. "Improvements in electric switches." A. Lindley. Dated April 15th.

9,597. "An improved electric reversing switch with liquid resistance." W. H. Vaughan and T. Foster. Dated April 15th.

9,616. "Improvements in and connected with coin-freed apparatus for administering electric shocks." H. J. G. Pessers. Dated April 15th.

9,631. "A new or improved plate for accumulators or electric storage batteries." J. Dunn. Dated April 15th.

9,675. "Improvements in and connected with electric clocks." L. A. A. Hennequin. Dated April 15th.

9,708. "Improved method of and means for preventing disturbances in telephone circuits by alternating current installations." O. T. Blathy and K. Kando. Dated April 15th. (*Complete.*)

9,748. "An improved method of protecting, supporting, and carrying electric conductors and other wires." G. E. Taylor and J. Eck. Dated April 17th.

9,770. "Improvements in gas lighting and in electric lighting for magnifying purposes and the application of same to lighting in general." J. Walsh. Dated April 17th.

9,800. "A new or improved process and apparatus for ascertaining, indicating, and recording by electricity the existence and position in the earth of metalliferous and adamantiferous layers or deposits, and of liquids in motion." C. de Ricaris. Dated April 17th.

9,803. "A voltaic battery having its depolarisation effected by heat." H. E. de R. de Lavison. Dated April 17th.

9,805. "Insulating materials for electrical purposes." A. Genizsch. Dated April 17th.